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Reinforced Concrete Construction in the Rebuilding of San Francisco.

Complete statements of the effects of the earthquake and great fire on the different classes of building construction in San Francisco have been printed in the recent issues of this journal. A careful scrutiny of these statements will convey a correct and complete impression of both sides of the effects upon all classes of structures, and it will be found that the first reports of the unsatisfactory action of both plain and reinforced concrete were without any foundation whatever. Even the wrecks of the buildings of Leland Stanford University failed to disclose any evidences justifying the earlier reports of the failure of reinforced concrete. Other masonry walls fell on all sides and many of them in complete and hopeless ruin, but the new so-called armored masonry stood the extraordinarily severe tests to which it was subjected in a most satisfactory and encouraging manner.

The rebuilding of the city is about to be begun and it is of the greatest consequence that the reconstruction be undertaken along lines justified by past experience not only in San Francisco but elsewhere, and with such materials as will be reasonably economical. The new structures must be as nearly as possible both earthquake resisting and fire proof. It is fair to presume that the days of the frame building are numbered. On the other hand, the judgment of those property owners in San Francisco who have erected tall buildings with steel frames in spite of the seismic character of the vicinity, has been completely justified. It has been shown that the well designed and constructed steel frame answers most admirably its purpose and that whenever damage may occur to the masonry filling of the wall, the frame itself is at least near enough earthquake proof to justify not only the extension of that type of building but also any other type offering equivalent stiffness with the same heights. These general observations must govern the building regulations of the new city if due regard is to be had for past experience.

The reinforced concrete-steel building has thus far been confined to a limit of height, not exceeding perhaps six to eight stories, indeed the greater of these heights may not even yet have been attained. While a building six to eight stories high is satisfactory and efficient for some localities and for some lines of business, it is not well adapted to those of portions of large cities where the steel frame lends itself to the attainment of much higher buildings. As a matter of fact, it is not difficult to design a concrete-steel building of almost any reasonable number of stories, provided the proper type of column is employed, as has already been observed in the editorial columns of The Engineering Record. With a well considered system of joints or connection details between floor-beams or floor-beams and columns, a highly economical and substantial building of perhaps ten to fifteen stories and of the reinforced concrete-steel type may be built. Such a building under proper supervision of construction may have the solidity of masonry and the stiffness of the stiffest steel framework, so as to meet the most exacting requirements of seismic disturbances, while abundant experience, not only in San Francisco, but in Baltimore and other places has shown that it will also possess as highly fire-resisting qualities as any material with which engineers are now familiar. There will doubtless be many buildings or parts of buildings which can be most advantageously constructed of plain concrete. The extraordinarily wide application of concrete in all classes of structures indicates with absolute certainty the important part which this material may play in the building of the new city. No influences whatever should be allowed to stand in the way of the utilization of so valuable a building material, in the use of which skilled labor is reduced to a minimum.

It is the last feature of the employment of concrete which may militate against that entire freedom of its application that ought to be found in a well-governed city. It is common knowledge that an extreme development of labor organizations has had a most unfortunate influence upon many municipal conditions in San Francisco, which ought to be free of any such control. This journal does not desire to even touch upon this feature of the labor conditions in San Francisco, but it would be an actual calamity if any labor or other prejudice should interfere with the free employment of the best material available in the enormous amount of building construction to be begun there. It is practically certain that the present conditions will stimulate immensely the cement manufacturing industry and the resulting conditions will be exceptionally favorable for the use of concrete. The interests of the entire city would be prejudiced by any sinister influence operating against an economical and substantial class of construction. The people of San Francisco owe it chiefly to themselves to see that the creation of the building regulations to govern the construction of the new city shall not be directed or controlled by any such sinister influence.

Report of the Royal Commission on London Traffic.

One of the most complete studies ever made in regard to the transportation facilities of any city has recently been completed by the Royal Commission on London Traffic. This commission may be said to have had its origin as a result of the famous controversy over rights of way and tube privileges several years ago between the Yerkes and Morgan interests. It was appointed by Parliament in February, 1903, to report upon the transportation requirements of London and the possibility of the appointment of a permanent tribunal to which all schemes of railway and tramway construction within the city should be referred. In the fall of 1903 five members of the commission, with the secretary, took a trip to this country and interviewed a number of the most prominent transportation engineers and experts, and during the last twelve months the commission has issued eight volumes of conclusions and testimony, of which the last to appear has just been issued. This volume is devoted almost entirely to the technical testimony obtained in America, and includes 1,250 closely printed octavo pages.

The subjects most thoroughly investigated in America were the franchise conditions in the cities visited; methods of relieving street congestion; the relative advantages of surface railways, shallow subways and elevated railways; the minimum width of street on which a tramway can be built to advantage; the effect of the operation of surface cars on street congestion; the influence of rapid transit systems and the American system of uniform fares on the distribution of population; the extent to which trunk line railroads can be utilized in solving intramural transportation problems, and the policies followed by municipal and state authorities in their treatment of local transportation enterprises. It is needless to say that the scope of the inquiry was so large that the commission secured an immense amount of information, much of which, they believe, will be of service in solving the problems presented in London.

Special attention was given to the effect of the operation of electric cars in crowded streets on the other vehicular movement, and it is interesting to note that the testimony in America confirms that brought out at the hearings in London, viz: that in all except the narrowest streets the introduction of electric cars improves traffic conditions. This is accomplished not only because a street car furnishes the most compact method of transporting a given number of people over a given distance, and thus reduces the number of vehicles on the street, but also because it gives direction to those remaining. This point was brought out not only by the street railway managers interviewed in America, but also by Capt. Piper, then second deputy police commissioner in New York, and who had made a careful study of street congestion. Another point into which the commission went very thoroughly was the relative merits of elevated railways and shallow subways. The latter form of road was considered with especial care because of the large number of deep underground roads in London, and it is interesting to note that the commissioners expressed their opinion very strongly in favor of the shallow rather than the deep underground railway. At the time of the commissioners' visit, the Boston subway was the only one in operation, although the New York subway was nearing completion, and its expected effect received careful consideration. Elevated railways receive short shrift in the published conclusions of the commission. While they admit that elevated roads "possess certain advantages as a means of locomotion" they state that "without going so far as to say that in no place and under no circumstances should an elevated railway be built, they are clearly not suited for London streets." On the other hand "the shallow underground railway is preferred to the deep level, and the latter style of railway will not be accepted unless when the former is out of the question."

The commissioners were very much impressed with the transportation facilities offered in our cities of the largest size, the extent to which they are used and the beneficial effect on both the social life and housing conditions of the inhabitants. In London, one of the commissioners in a separate report states, the suburban inhabitant is in the town but not of it and is practically debarred, owing to lack of transportation facilities, from many of the advantages of town life.

Outside of the Brooklyn Bridge crush, which seems greatly to have impressed the visitors and which they say has no parallel in London, there are two points other than those mentioned to which considerable space is given and which seem worthy of comment. One is the hearty indorsement given, even within the crowded portions of the city, to surface tramways in which London is now woefully lacking and which supply a need which is not filled by any other transportation agency. The other is the commendation of the American system of uniform fares which, while not positively endorsed for European conditions, is at least considered desirable in principle.

Railroad Development Towards New Orleans.

In the issue of The Engineering Record of a week ago, editorial comment was made on the possible bridging of the Mississippi River for railroad purposes at Baton Rouge. This bridge project has somewhat more significance than may at first sight appear. It is one indication of an extensive railroad development now taking place from Illinois to New Orleans, although this proposed bridge is not a necessary feature of that development. Nor is this stimulation of railroad building and rebuilding confined entirely to the Mississippi Valley, as the Southern Railway, for instance, is largely increasing, or extending its facilities for contributing its share of business to the port of New Orleans.

The period of active trunk line railway building so prominent in the earlier days of the great Western, Southwestern and Southern systems is so completely a matter of the past that this great enhancement of the capacities of railway lines tributary to New Orleans has failed to receive the attention to which its magnitude and importance entitle it. There is scarcely a large railway system even indirectly tributary to New Orleans to which that observation does not apply. The so-called Vanderbilt railway lines are not usually considered as catering to traffic seeking the port of New Orleans, and yet they have recently been engaged in constructing and are now reconstructing connections with the Mobile and Ohio system at Cairo. A railway line has already been built from Indiana Harbor, at Chicago, to Danville, Ill., and what is practically the rebuilding of the Cairo division from Danville to Cairo, is now under way. These connections with the Mobile & Ohio at Cairo bring the Vanderbilt system quite within the lines tributary to New Orleans. The extensive ramifications of that system throughout what may be called the Central West will enable a large amount of traffic from that territory to be advantageously shipped over the Mobile & Ohio system directly to the great Gulf port.

The Illinois Central system has occupied for many years a position admirably adapted to highly economical handling of North and South traffic originating almost anywhere in the Mississippi Valley from the mouth of the Missouri to the city of New Orleans. It has not only been a great traffic channel, so to speak, to that port, but it has also been a great distributing agent for all classes of traffic either passing through or originating at that point and destined for that central portion of the country which includes both the Mississippi Valley and a great extent of territory adjacent to it. This system has not only been increasing its capacity by greatly improving its lines already existing, but also by the construction of a large amount of new work in Kentucky, Tennessee and Mississippi. Its great terminal plant in the city of New Orleans, the Stuyvesant Docks, has been entirely rebuilt and much enlarged since it was destroyed by fire. This reconstructed terminal was described in The Engineering Record for June 23.

The Rock Island system has for some years been reaching out into the Southern and Southwestern fields, much of which are tributary to New Orleans, largely by means of the St. Louis & San Francisco lines. The latter have extended southward from Memphis and new lines are now being constructed in Missouri and Arkansas leading south and adding to the general development in the direction of the mouth of the Mississippi.

Among the older lines which have always been prominent in the Southern and Southwestern trend of their business is the Missouri Pacific. Although it has always had, so to speak, a kind of mortgage on a large part of the Southwestern traffic seeking Gulf ports, it has not made a special point of New Orleans traffic; but it also has now extended its lines southerly into Arkansas in such a way as to be headed toward the lower Mississippi. While this development of the Missouri Pacific is much less pronounced in its trend toward New Orleans than the extensions and reconstructions by some other lines it is certainly adapted to reaching that port as an objective, and there can be little or no doubt of the purpose to secure as much of that traffic as possible.

The Southern Pacific system has, of course, always been a great feeder to New Orleans as well as to other Gulf ports farther west. It is so preeminently tributary to that port that it must, necessarily omit no effort whatever to keep the growth of its facilities equal to the largest demands that can be made upon them to serve all traffic within its reach either into or out of New Orleans. Its lines through Louisiana and the eastern part of Texas have required the construction of many bridges which, as in many other cases, has limited its engine and train loads. These bridges have within a comparatively short period been largely reconstructed so as to meet the requirements of heavy engine and train concentrations thus enabling it to maintain its advanced position as a great freight carrier to its Eastern terminal.

Finally the Southern Railway system, tributary to New Orleans from the East, has been no less active in increasing its capacity for delivering freight to that point than in other parts of its system. It has probably expended not less than $20,000,000 for the double tracking and other construction, or reconstruction of those of its lines carrying traffic to New Orleans.

On the other hand the great Chalmette Dock system of the New Orleans Terminal Co. affords extensive deep-water accommodations ten miles below the city, and on the east bank of the river for the heaviest shipping seeking the port. This terminal company, it is understood, has not only awarded construction contracts to the amount of $10,000,000, but it is also to have a great passenger terminal in the heart of the city.

This extraordinary development of railway lines throughout the central portion of the United States tributary to the greatest of the Gulf ports possesses unusual significance. The growth of foreign business for all the Gulf ports has for a number of years been observed and remarked upon, and that alone is doubtless a sufficient reason for a substantial increase of facilities for all the railways converging to them, but even that can scarcely account for the great railway development in progress to serve the port of New Orleans. Undoubtedly the certain construction of the ship canal across the Isthmus of Panama is the additional source of stimulation of the railway activity commented upon. The Gulf ports cannot fail to feel the beneficial effects of the completion of the canal to a marked degree, and the port of New Orleans, at the entrance of the Mississippi Valley, is unquestionably destined to the most highly favored in the resulting growth of its commerce.

Civil Service and the Engineer.

The extension to engineering organizations of civil service methods for selecting and promoting employes seems to be well established, not only in the national government but also in many of the States and larger municipalities. The underlying theory of selection, retention and promotion according to merit is good, but the test of merit is an examination necessarily restricted in scope, and therefort frequently an unsatisfactory test. Civil service control of labor, clerical and uniformed forces in public service has unquestionably accomplished much good, more in some places than others, for civil service like other civil institutions is no better than it is made by the people who use it. A community with low standards of civic virtue will have more or less corruption in public service even under civil service restrictions, for even the civil service will be apt to be administered by selfish and unscrupulous men with improper ends to be served. But the application of civil service to engineering and other professional branches of public work requiring technical training involves special difficulties which have nowhere as yet been satisfactorily solved, so far as this journal has been informed.

Where The Engineering Record has had opportunity to observe, the methods of conducting examinations, the standards of excellence demanded, the nature of the examinations, and the rules governing appointments, promotions, transfers and dismissals differ greatly. Young engineers who have received high rating in one State or city have failed to pass in another. Men who for ability, experience and good personal qualities, in addition to technical training, would be selected without hesitation by a careful employer, have received relatively low rating, while men of lesser worth who have acquired a facility in civil service examinations are at the heads of eligible lists in many cases. This undesirable result of the examination system is unavoidable, but its baneful effects could be counteracted to a great degree if rules governing selections for appointment could be adapted more closely to the requirements of a technical organization. More freedom of choice should be granted, particularly for filling positions having duties requiring special attainments. If a choice of one out of three certified eligibles is sufficient for filling a clerical position, it does not follow that this is a suitable range of choice for a technical position. Why should not a civil service commission certify from five to ten names for a technical place according to its importance?

In some places, proceeding on the assumption of the innate depravity of all men, rules have been elaborated with such care to prevent rascals from doing wrong that it has become exceedingly difficult for an appointing officer seeking only to accomplish the public work in the best manner, to organize and maintain an efficient corps. Some systems have become so intricate as to consume, in a large organization, much of the time and thought of a bright man in one of the higher positions, such as the chief engineer or his principal assistant, aided by several clerks, in order to secure men fitted for the positions; weed out the incompetents in such a way as to avoid legal suits; see that every jot and tittle of the law is fulfilled with respect to each man so that pay-rolls will not be held up by the scrutinizing clerk in some one of the offices through which the rolls have to pass before payment is authorized; and to keep track of the scores of other details, failure in any one of which would make much trouble.

There is another element to be taken into the reckoning when considering the application of civil service regulations to a large engineering force, namely: the cost—and there are some items of cost which are usually lost to sight. Of course, the expenditures for the civil service board and its corps of examiners and clerks are evident enough, and to average on this basis the cost per appointment is a matter of simple bookkeeping. This, however, is not the total cost. The charge on account of the misapplied time of the chief engineer and others in the office to which appointments are made, as suggested above; the loss due to having in a given position a man only partially fitted for it, because he is the best man to be obtained from the eligible lists, while just the right man, although known and practically available, cannot be employed on account of the civil service restrictions; the necessity for overloading a force, or hiring men before they are needed in order to seize an early opportunity to use an eligible list when it becomes available, and the losses due to delays, frequently serious, in securing men—not to enumerate many other indirect costs—are not so easily entered in the books; but they are a burden upon the tax-payers, nevertheless, and make the engineering charge on a piece of public work seem larger than it really it.

However, there is no necessity of continuing a recital of all the annoyances great and small incidental to conducting engineering work under civil service conditions which have come to the knowledge of this journal. It is purposed not so much to find fault with civil service methods, although an engineer is often and with reason provoked to do so, as rather to suggest that engineers in places of responsibility and influence make every endeavor to improve matters by co-operating with the civil service authorities. In more than one place civil service commissioners have exhibited an earnest and commendable desire to meet the needs of the engineer to the best of their ability, within the law. If instead of finding fault the engineer will point out how the needs of his work can be better met, suggest improvements in the examinations and aid, in so far as he properly can, in selecting competent technical examiners, much more good will be accomplished. Especially let him master the civil service regulations and practice under which he has to conduct his work and learn to make the most of them. He may be pleasantly surprised to learn how much and how good results can be accomplished with this imperfect tool, if it be used skilfully.

Since civil service regulation of engineering forces engaged on public works seems to be an accepted institution, it becomes incumbent upon the engineers occupying or seeking responsible positions connected with such works to familiarize themselves with civil service practice. It is unfortunate that the practice is so various, but probably no men are so well qualified or have such opportunities to aid in securing uniformity as the engineers, whose work takes them into different parts of the country for successive engagements.

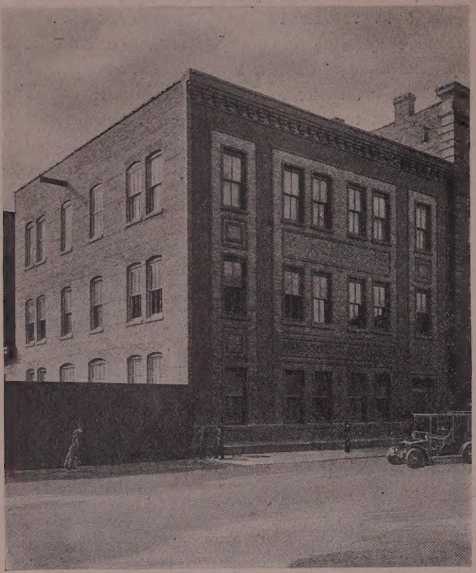
This leads to another suggestion. In large public works, like many now in progress, some of the brightest as well as the average engineering graduates will find an attractive field for their activities and ambitions. Let false notions about red tape and politics be overcome and let young engineers and older practitioners steadily stand together to keep politics out. It is time for engineers to appreciate and properly use the power and influence which has really come to be theirs. This is well illustrated by a remark made not long ago by a prominent politician in one of our largest cities to one of his colleagues. "The engineers really run our big cities nowadays, at least so far as public works are concerned; not one of us dares to do a thing any more without an engineer back of him." A chief engineer with back-bone can keep his force comparatively free from improper political influence, if he will, even in a corrupt community. This will require much tact, diplomacy and firmness, together with the support of public spirited citizens of influence. The engineer will have to learn also that the recommendations and requests of politicians do not always or necessarily have improper intentions.

But to return to the young graduate. Civil service systems in many places are complicated and he does not know how to "get aboard." Here is room for some useful instructions in the senior year of a technical course. Why should not the engineering colleges inform the young men of the details of the right mode of procedure for securing employment in the civil service of the national government and at least one or two of the States and large cities, selected according to the location of the college? Copies of the rules and sample examination papers could be secured for the college library, and at proper times could be explained to the senior classes.

Geographical restrictions for entrance to the examinations are often too narrow, especially for engineers, who perforce are more or less nomadic. Communities in their endeavor to give preference to home talent frequently deprive themselves of the services of some of the ablest among the younger technical men. Because it is advisable that the laborers, policemen and clerks in a city's employ should reside within its limits, it does not follow that it is good public policy so to restrict its engineer corps in a similar way.

Civil service regulations have not been applied to engineering work with proper understanding of the special requirements of such work. It does not therefore follow, however, that civil service methods should be totally condemned. The lesson is rather that engineers should use their influence as loyal members of the profession and good citizens to bring about a better adjustment.

One of the Greatest Single Features of the immense work before the engineering organization of the Board of Water Supply of the City of New York is the location of the great 500,000,000-gal., or more, aqueduct leading from the Ashokan reservoir in the Catskill region to the city, particularly that part of it on the westerly side of the Hudson River, for 30 to 40 miles. It is understood that a large portion of the engineering force of the Board is now out working in the field, engaged on this location, and that the engineering work is supplemented by geological investigations conducted by Prof. Kemp, of Columbia University, and Prof. Crosby, of the Massachusetts Institute of Technology. The Hudson River crossing of the aqueduct, which must be in deep tunnel, constitutes an important detail of this particular work. Surveys of its lines are not only in progress, but a large amount of jet boring and diamond drilling to depths of even 300 or 400 ft. have been made and are now in progress. Whether that portion of the aqueduct line west of the Hudson shall lie relatively near to that river with much deep and high-pressure tunnel and a deep river crossing near New Hamburg, or whether it shall lie further west, where bed-rock is materially higher, thus greatly reducing high-pressure tunnel work, and with a river crossing somewhere in the general vicinity of West Point, can only be determined when the requisite examinations are completed. All this work lies within what may be termed routine investigations connected with such a great public water supply project. It does not signify that special difficulties have been found in one place or another, but simply that the engineering organization of the Board of Water Supply is thoroughly performing the duties which properly belong to it. Some absurdly sensational reports in the daily public press have been printed in connection with the work of this aqueduct location. The mal-directed imagination of the reporter resulted in such a grotesque distortion of the facts that it amounted to gratuitous misrepresentation. As a matter of fact, the entire work of the Board is progressing in a most satisfactory way, with promise of considerable work being put under contract before the year's end.



The Underwriters' Laboratory, Chicago.

The Underwriters' Laboratory Plant in Chicago.

The new laboratory plant of the National Board of Fire Underwriters in Chicago is supported by the stock fire insurance companies doing business in the United States. The investigations carried on in the laboratories of this plant are devoted exclusively to experimental work in fire protection engineering and to the testing of devices and materials having a bearing on the fire hazard. The plant occupies a 100x100-ft. site on Ohio St., just across the Chicago River from the main business district of the city. This location is not only easy of access from the business district, but also permits the connections of large capacity for supplies of electric current, gas and water essential in the laboratory work, to be readily secured. The laboratories are in a 50x100-ft. building which has a 3-story and basement section, 50 x 50 ft. in plan, at the front, with a one-story annex, 50 x 50 ft. in plan at the rear of this 3-story section. The other half of the 100x100-ft. site is devoted to testing apparatus that is more conveniently operated in the open.

The structure containing the laboratories was built according to the most advanced standards for fireproof factory buildings, and is considered to be a model for buildings of that type. The building being only 3 stories in height, with a basement, a steel frame was not required for it. The exterior walls are of hard-burned brick. The floors have structural steel beams and girders, which are carried by the exterior walls and by cast-iron columns protected from fire by hollow tile. The girders and beams of the roof and floors are also protected by hollow tile. All floor, roof and partition construction is of semi-porous hollow terra-cotta tile with thick walls. The partitions are all self-supporting. The openings in the partitions are framed with structural steel channels, which form the final finish for such openings.

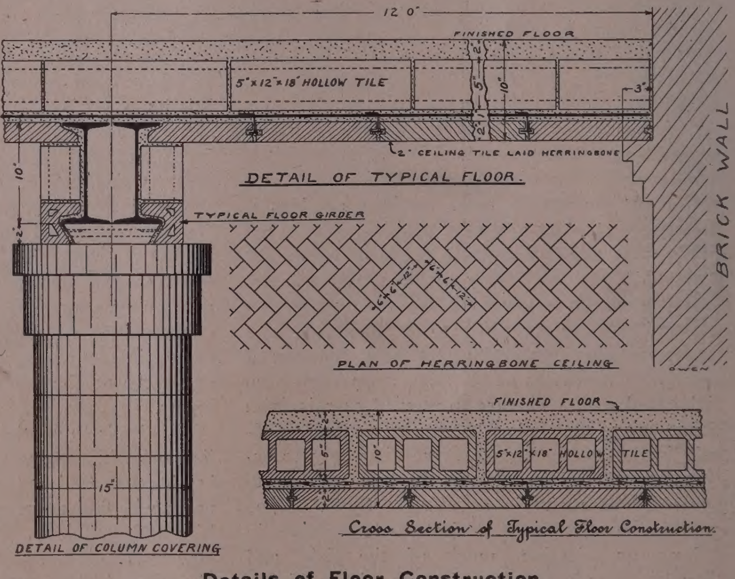
The roof and floors were built according to the Johnson tension system by the National Fireproofing Co. That company also supplied and erected the protection for the cast-iron columns and the steel floor beams and girders. The details of the floor construction are shown in the accompanying illustrations. The floors are 10 in. thick, the bottom of each floor slab forming the ceiling of the story below. The ceiling consists of 6x12x2-in. tile, which were first laid herringbone on temporary flat board forms built up on centering from the floor below. Over these 2-in. tile is placed a 1-in. layer of concrete containing continuous lengths of woven wire cloth for reinforcement. The 2-in. tile are suspended from this wire cloth by metal clips set in grooves cast in the four edges of each tile. Over the 1-in. layer of concrete is placed a layer of 5x12x18-in. hollow tile, laid in cement mortar. The tile is covered with 2 in. of concrete, which has a surface coat of cement mortar that was floated smooth as it was laid.

A stairway leads from the first to the third floor at one corner of the front of the building. This stairway is all enclosed by partitions composed of two thicknesses of 3-in. hollow tile. Each staircase is 4 ft. wide in the clear. The steps are each a single piece of hollow vitrified terra cotta. They have molded nosings and smooth, glazed surfaces, their tops and bottoms being equally prominent. On the exterior wall side of the stairway the steps are built into the pressed brick facing of the wall. In the center between the flights, they are built into double partitions of hollow tile, so no balastrades or railings were required. The construction of the landings between the flights is the same as that of the floors in the remainder of the building. The construction of these stairs is said to be cheaper than that of wooden stairs, while at the time they are certainly as sanitary as any form of construction that could be employed.

A vault is built on each floor in the same corner that the stairway occupies. These vaults are also enclosed in double partitions of hollow tile which extend from the basement to the roof, and carry a double I-beam roof or floor girder at each story.

The second floor is used for offices and record filing rooms, but the basement, first and third floors are devoted exclusively to laboratory work. The walls of the building are not plastered in any place. The interior surface of the outside walls in the second story and in the stairway are finished with dark red hard-burned pressed brick. The interior surfaces of the walls in the remainder of the building are simply the regular hard-burned building brick. The joints in the exposed surfaces of the tile fireproofing were raked out and pointed with cement mortar, which is tinted the same color as the tile and resulted in a quite uniform surface appearance.

The frames and sashes of the windows and skylights are all sheet metal. The windows and skylights are glazed throughout with wire glass, eighteen different types of windows being used. The doors are all double sheet copper or sheet steel filled with wood. The rear of the first story is exposed across a 16-ft. alley to an ordinary brick stable building. The only door in this wall is fitted with a rolling-curtain fire door on the outside and with an automatic sliding fire door on the inside. The laboratory building is to be fitted throughout with an automatic sprinkler system.



Details of Floor Construction.

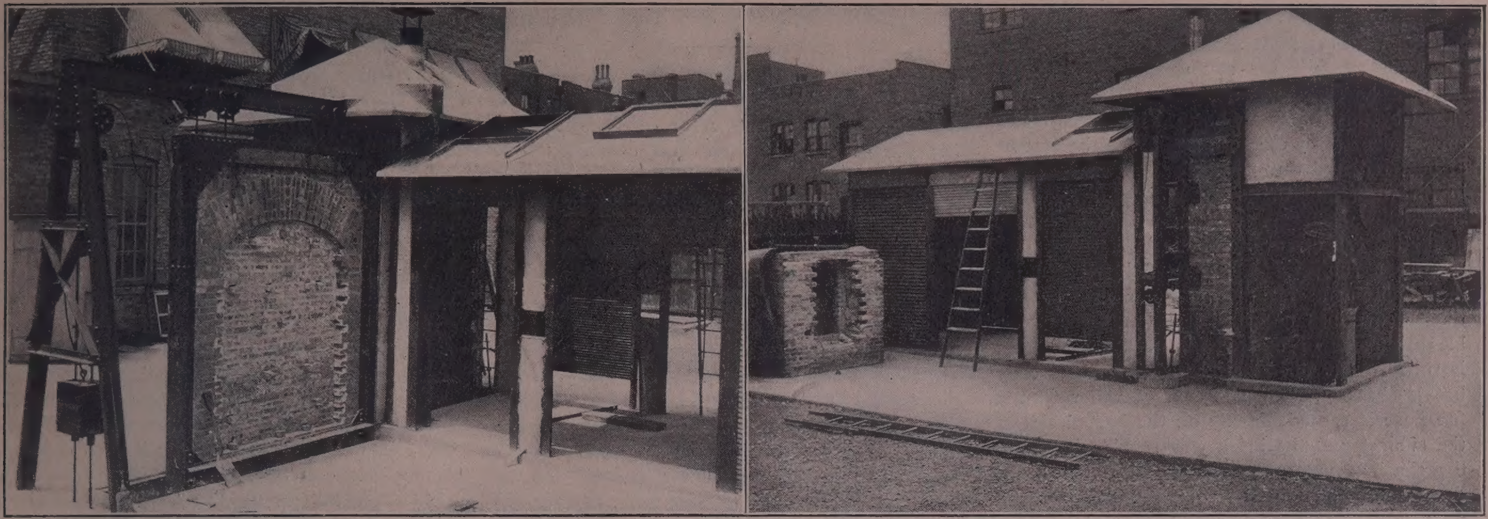
The furniture in the offices is all of sheet metal. The floors of the offices are finished with a resilient cement mortar, colored red. The front door of the building is of an ornamental copper design. Otherwise than such changes as these and those heretofore described, the building is built according to plans that would be adapted for factory purposes. At the present prices of lumber in Chicago the increased cost of the construction of this building over the cost of erecting a structure of similar size according to the requirements for slow-burning mill construction would be about 14 per cent., excepting the trimmings in this building unnecessary in a regular factory building.

The basement and the first floor of the building are largely devoted to apparatus for hydraulic testing. A 1,000-gal. Underwriters' screw fire pump, driven by an enclosed electric motor is installed on the first floor. This pump is supplied from a 10,000-gal. storage tank in the basement and is operated in connection with a 5,000-gal. steel pressure tank on the first floor. A 50-gal. pump of the same type is also installed. Air is supplied to the 5,000-gal. pressure tank by an automatically operated motor-driven compressor, which maintains a uniform pressure in the tank. A 75-ft. steel standpipe is also provided for static heads.

The basement is largely devoted to apparatus for testing different types of valves, gates and hydrants for water supply and distribution pipe systems. A line of 6-in. pipe laid on the basement floor is provided with a number of fittings to which the various types of subjects may be attached. Each of these fittings is independently connected with a supply and discharge main. Water under pressure is supplied from the 5,000-gal. tank, or from the 75-ft. standpipe, pressure up to 200 lb. per square inch being available from the former. Each connection with the supply and discharge main is fitted with a quick closing valve so the water supply may be quickly cut off in case a subject fails under test. A small hatchway built in the first floor over one end of this valve testing apparatus is so arranged that a full-sized fire hydrant and all of its connections may be tested readily, the upper end of the hydrant extending above the first floor line.

On the first floor, connections are made for testing various types of fire hose and nozzles, the water being discharged back into the 10,000-gal. tank in the basement and used repeatedly. The concrete floor of the rear portion of the first story is drained toward the center and is arranged so tests of other hydraulic devices may be carried on in this portion of the building. With the exception of electrical apparatus, all sorts of lighting and heating devices, including acetylene gas generators, gas and gasoline stoves, etc., are also tested in the rear portion of the first story.

A section of false wooden ceiling is erected in the center of the rear half of the first story of the building. This ceiling is used for testing the distribution of automatic sprinklers and is



Two Views of Gas-Fired Testing Oven; a Brick Partition Built into Rolling Door, Shown in Left-Hand View.

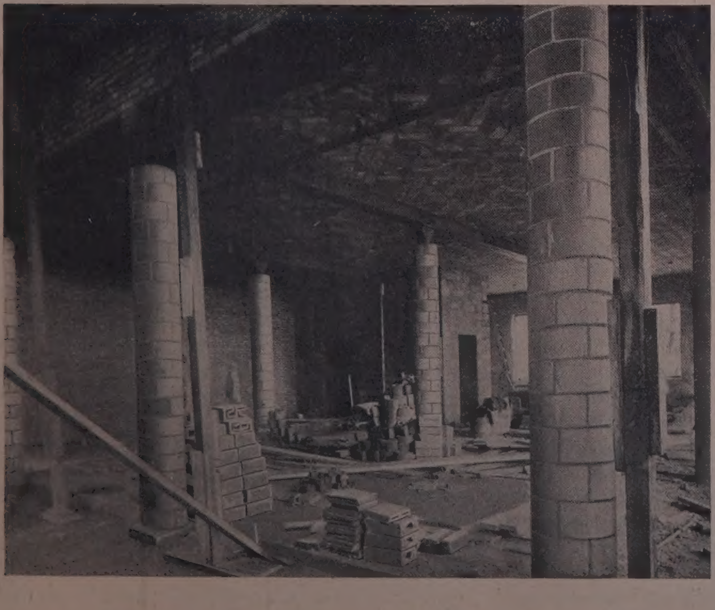
adjustable so plain, flat, joist or mill-construction floor systems may be duplicated. The connection to which the sprinkler tip is attached is arranged so it may be set at different distances below the ceiling, and is supplied with water from the pressure tank. Sprinklers are tested for leakage by a hand-wheel hydrostatic pressure ram equipped with a spring gage reading from 0 to 2,400 lb. per square inch. They are attached for these tests to connections with a heavy L-shaped cylinder, the upper end of which is used as an expansion air chamber, and are tested under a constant hydrostatic pressure of 300 lb. per square inch for 3,700 hr. Sprinklers are tested for water hammer by being attached to a system of extra heavy brass pipe, one end of which enters a vertical cylinder provided with an upright movable plunger. The cylinder and pipe system are filled with water, the plunger being forced to the topmost point of its travel, then a weight is dropped on the top of the plunger from a predetermined height. The pressures developed are measured by a Crosby indicator of special construction.

The remainder of the sprinkler tests are made in a separate room at the front end of the first story. The temperature at which a sprinkler will be started to operate is tested in a specially designed hot-air oven of unusually accurate construction. The fusing point of standard degree sprinklers is also tested in water, and that of high degree sprinklers in hot oil.

Half of the third floor is devoted to an electrical laboratory and the other half to a chemical laboratory, and drafting, instrument, photography and storage rooms. Electrical fittings of every kind are tested in the electrical laboratory. A specially designed transformer provides current at 40,000 volts for breakdown tests. The secondary of this transformer is divided in ten steps, which, together with the variation of the primary voltage, enables almost any voltage up to 40,000 to be obtained. A 10-kw. alternating-current generator driven by a motor furnishes current for the transformer. The motor driving this generator also drives a 600-ampere, direct-current generator, which supplies current at 7 volts for testing high-tension fuses. Fuses, cut-outs, lamp sockets, etc., are tested at a board properly wired for such work. Push button switches, snap switches, etc., are tested by different kinds of apparatus driven by a constant-speed motor.

Some of the most important work done in these laboratories is the testing of fire doors and shutters, metal window frames and sashes, wire-glass, various kinds of materials for partitions and large subjects of this character. This work is all done in a special oven, the design of which is the outgrowth of a number of years of experience in such work on the part of the engineering staff of the laboratory. The oven is built of brick laid in cement mortar, the portions of it exposed to high temperatures being built of fire-clay brick. The oven stands on a broad concrete base and is covered by a ferro-inclave roof. The subject to be tested is built into a brick wall, 18 in. thick, in the same manner that it would be built into a building wall. This brick wall is made as a rolling door and forms one side of the oven. It is built in a frame of structural-steel shapes suspended on rollers on an overhead steel track, so it may be pulled to one side of the oven on this track, which is about 20 ft. long.

The oven is fired with illuminating gas mixed with air after it has entered the combustion chamber. The wall of the oven on the opposite side from the rolling brick door is quite thick and has a recess in its inner face that forms the combustion chamber of the oven. The gas is introduced into the oven through four pipe connections spaced across this wall at the same level near the bottom of the latter. The air is supplied under pressure from a motor-driven fan on top of the oven. It is introduced at the quarter, half and three-quarter heights above the bottom of the wall through four pipe connections at each height. The air and gas connections are so arranged that the supply of either may be varied to suit the intensity of flame desired. With this arrangement for firing and the gas fuel used, a uniform sheet of flame can always be secured, which practically duplicates actual fire conditions. Electric and water pyrometers are both used in determining the temperature in the oven.



View in First Story during Construction.

Men Pointing Joints in Ceiling of Second Story.

A structural steel frame, 12 x 20 ft. in plan and covered with the same roof that is over the oven, is erected against the rolling door side of the latter. The sides and the end of the room enclosed by this frame are formed by rolling steel-curtain doors. By closing these doors the amount of heat radiated through the subject being tested in the oven and the distance from the subject at which various materials in a building would be ignited can be readily determined.

After a subject has been tested according to the requirements for the particular class of protective coverings to which it belongs, the portable brick side of the oven in which it is built is rolled out to one side on the track, before the fire is shut off, then a stream of water from a fire hose is turned directly on the heated side of the subject and the brick work. This is one of the chief advantages of having the subject under test mounted in the rolling door, as it permits actual fire service conditions to be carried out in a way that is possible with no other form of testing oven.

The results of the tests and investigations carried on in the laboratory are incorporated in reports which are first approved by the chief engineer of the laboratory. Each report is then sent to every member of a committee of from 11 to 25 engineers from all sections of the country, who are specialists in the particular subject covered by the report. These committees of engineers are separated into those on protection, extinguishers and retardants, on electricity and on gases and oils. If a report is unfavorable to a majority of the committee, further tests and investigations are carried on in the laboratory along lines suggested by the committee. When a report has finally been approved by the committee, the results are filed in the office of the laboratory. The card index system is employed in filing the results contained in these reports. Branch offices of the National Board of Fire Underwriters, as well as all of the principal fire insurance companies throughout the country are furnished with a complete system of these cards, which is kept up to date from the laboratory. In this manner it is possible to learn in any of the cities where these offices are located whether an article, a class of material, or a piece of apparatus to be used for fire protection, or having a bearing on the fire hazard has been tested by the National Board of Fire Underwriters, and the opinion of the engineers of that Board regarding such subjects, if they have been tested.

The laboratory plant was built and is operated by the Laboratories Corporation, of which Mr. H. C. Eddy is president, and Mr. W. H. Merrill, Jr., is secretary. The engineering staff of the laboratories is as follows: Mr. W. C. Robinson, chief engineer; Prof. Fitzhugh Taylor, hydraulics; Mr. W. H. Forster, chemicals, gases and oils; Mr. Dana Pierce, electricity. The laboratory building was designed by Mr. Argyle E. Robinson, architect, of Chicago.

Wood Preservation with Sulphur is being exploited widely in Germany. The sulphur is applied in liquid form and in hardening completely fills all the cell spaces of the wood fibre. Although the sulphur oxidizes easily if subjected to a high temperature, it is said to remain impassive at a moderate temperature, resisting not only the influence of water but also that of acids, concentrated or diluted and of alkaline solutions, if cold. Since sulphur melts at 115 deg. Fahr., the feasibility of using it on wood that is to be employed in outside construction in practically every part of this country is to be questioned. In numerous experiments poplar has been found to be the best wood to take the sulphur treatment, while oak and pine are not so well adapted to the process.

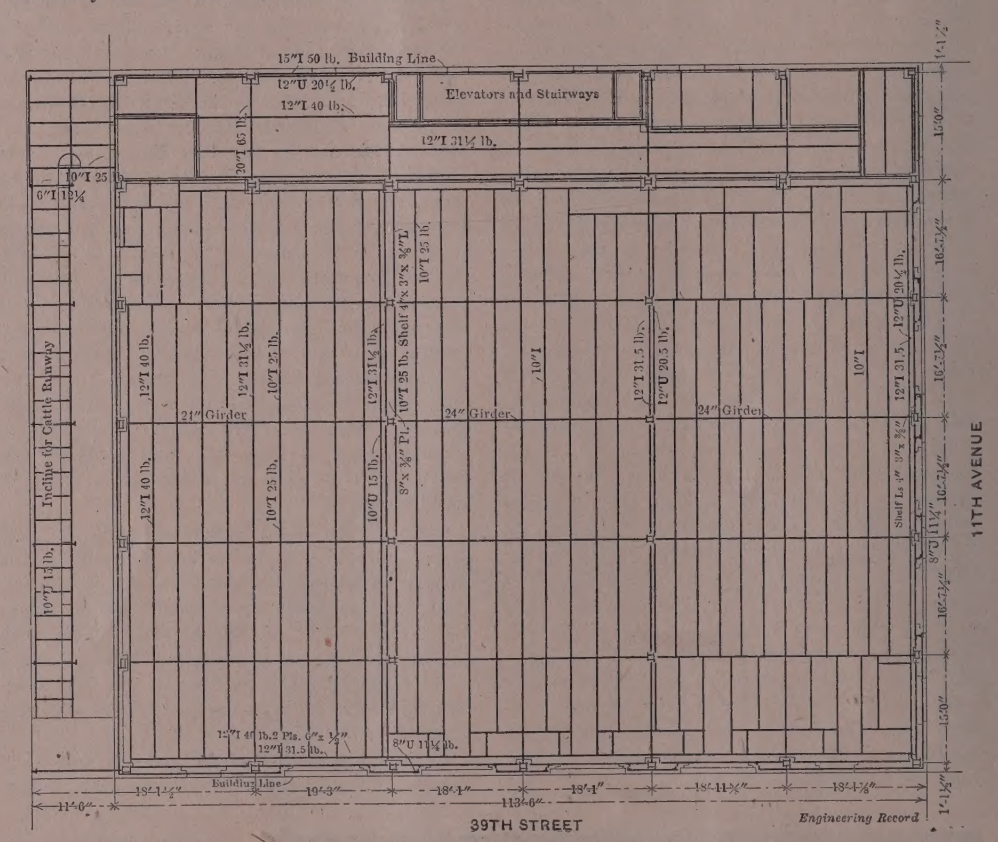
Construction Features of a Model Abattoir.

The general arrangement and equipment of the model abattoir in New York City was fully described in last week's issue of The Engineering Record. The design and construction of the buildings of this plant are as interesting as are its arrangement and equipment and are fully described in the following article. The abattoir building is a 99x125-ft., six-story structure about 120 ft. high above the first-floor level and was completed in 1905 at a cost of about $600,000 exclusive of the site. It provides for the temporary shelter of live stock and for the killing, dressing, storage and shipment of meat which is largely used for the Hebrew trade in New York and vicinity. The necessity for the abattoir is partly due to the fact that the religious requirements of Mosaic law prevent the use of meat that has been killed for than a given time, therefore limiting the conditions so that often meat cannot be used in New York that has been dressed in the western cities. Special provision is therefore necessary for the trade in this city and has resulted in the construction of this abattoir, which is the largest and most modern of several abattoirs occupying the very limited area of the only district on the west side of Manhattan Island where the slaughtering of cattle is permitted by the city ordinances.

Before the plans for the abattoir were made Mr. Arthur J. Horgan, of Horgan & Slattery, architects, visited all of the principal abattoirs in the United States and Canada to study their construction and operation, after which the design was prepared with the intention of combining and improving the best features of existing plants and securing the highest degree of sanitary excellence, rapidity and economy of operation and durability of construction. This resulted in some special features of design and equipment which have been described in the article referred to and others will be described in subsequent issues of this journal.

The framework of the building is of structural steel, the floors and roof are of concrete and the walls are of brick with sandstone trimming. The minimum quantity of wood is used for some of the floor surfaces, windows, doors, etc., and great care has been taken to fireproof the steel and to provide non-absorbent surfaces wherever they are required by sanitary conditions.

The building is a detached one, and as the upper stories are exposed to prevailing winds, a horizontal pressure of 30 lb. per square foot in any direction was assumed and is calculated to be resisted by the inertia of the building, the stiffness of the floors and partitions and by the rigidity of the beam and column connection, no special bracing having been found necessary by the computations. A live load of 120 lb. per square foot was assumed for the fifth and fifth mezzanine floors. All other floors were designed for a uniform live load of 150 lb. and dead load of 100 lb. The usual custom of assuming that only a portion of the successive floors were simultaneously loaded was not followed in this case, and the above loads were assumed to produce their complete summation in the lower sections of the columns.

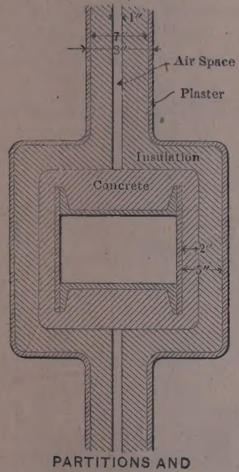


Fourth Floor Framing Plan.

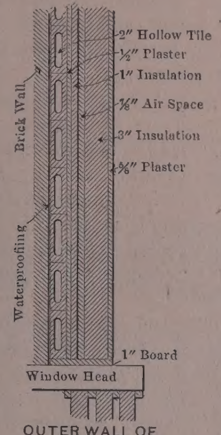
The roof is occupied with covered pens for the temporary accommodation of live cattle, the fifth mezzanine floor is used for keeping and killing sheep and calves, the fifth floor being used for killing large stock.

The fourth story contains the fat-picking department, chill rooms, working corridors, toilet rooms and refrigerating apparatus. The third story contains beef cooler rooms, working corridors and toilet rooms. The second story contains general and private offices, directors' rooms, beef coolers, toilets and working corridor. The first story contains beef coolers, working corridors, tank room, salesroom, cash offices and street loading platforms protected by awnings, with steel frameworks covered with copper and polished plate wire glass. The basement contains small stock coolers, salesroom, working corridor, pickling rooms, salt storage, ice box, toilet rooms, time keepers' rooms and small offices, and communicates directly with the street by four independent outside stairways enclosed by cast-iron and polished plate wire glass storm houses.

The basement does not extend beyond the building line on one side, but on the other three sides it extends about 12½ ft., 15 ft. and 20 ft. respectively beyond the exterior walls, thus providing wide sidewalk vaults which are enclosed by a concrete retaining wall having a framework of vertical and horizontal I-beams and channels. The general excavation is carried down to a depth of about 14 ft. below the street level where grillages from about 3 to 7½ ft. wide are made with 10 and 12-in. I-beams enclosed in concrete to distribute the column loads and reduce the pressure to about 30,000 lb. per square foot. The grillages, except the smallest ones, have an upper tier of three or four transverse 15-in. I-beams which receive the riveted-column bases and distribute their loads. The surface of the rock is in most places near the basement floor and rectangular concrete piers a few inches wider than the grillages are built on it to carry the latter, and are continued above the grillages to enclose them, the distributing girders and the feet of the columns, the latter being about 6 in. below the concrete floor in the basement.

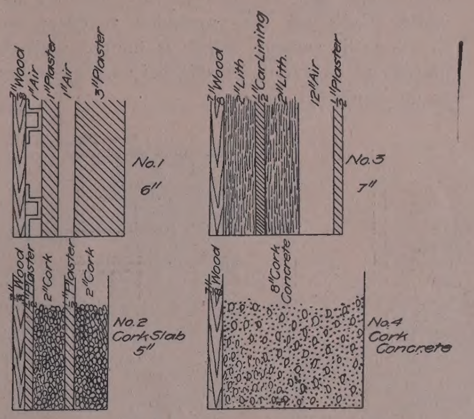


PARTITIONS AND COLUMN INSULATION

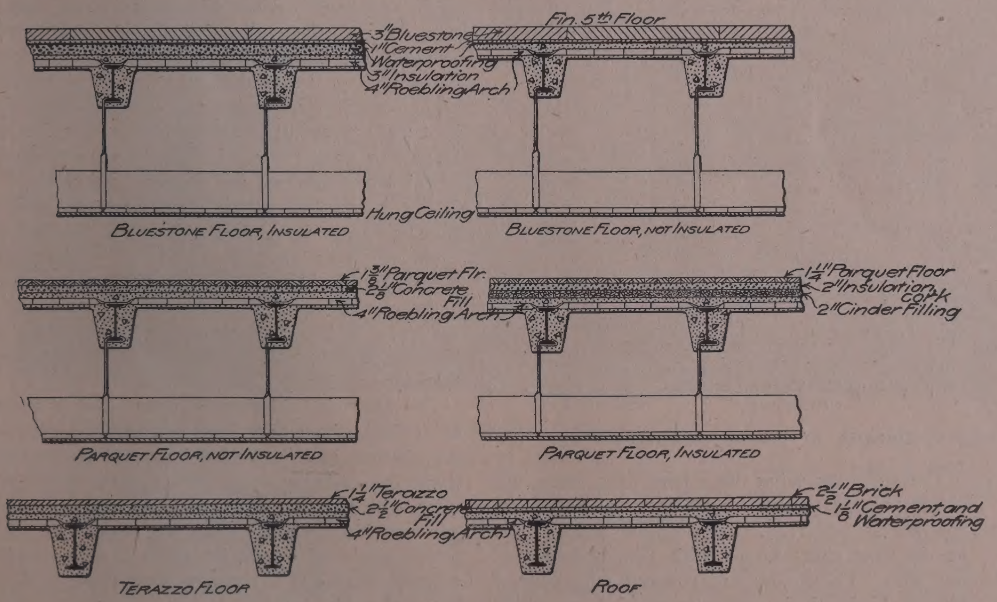


OUTER WALL OF REFRIGERATING ROOM

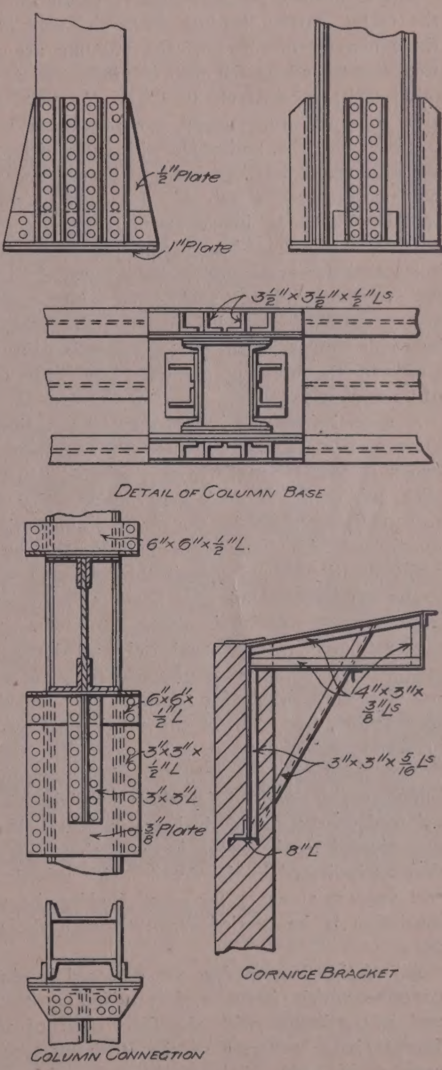
Engineering Record



Materials and Arrangement of Insulation in Comparative Tests.



Details of Various Floors in Abattoir.



Details of Typical Steel Framework.

All columns are arranged at the intersection of lines about 19 ft. apart transversely and 16½ ft. apart longitudinally. They have closed rectangular cross sections made with a pair of channels and two cover plates. The upper sections of the lightest columns are proportioned for a load of 45,600 lb., and are made with a pair of 9-in., 13¼-lb. channels and two 12x⅜-in. plates giving a gross cross section of 16.78 sq. in. The sections are increased in the lower stories by increasing both the size and thickness of the plates and channels, the maximum having an area of 95.4 sq. in., composed of two 15-in., 33-lb. channels, two 16x¾-in. plates, two 14x⅝-in. plates and two 14x⅜-in. plates as required for the load of 1,228,500 lb.

All columns are made in two-story lengths with field-riveted splices just above the finished floors. The feet have extended base plates thoroughly stiffened with gusset plates and with vertical angles proportioned to distribute the total loads equally through the girders on which the column is seated. The I-beams are web-connected to the webs or cover plates of the columns, and plate girders are seated on horizontal bracket angles reinforced by vertical distributing angles under the girder webs as indicated in the accompanying typical connection.

The framing of the beams and girders in the floors and roof is very simple and regular, except where some of the columns are replaced by plate girder spans. The requirements of the killing floor necessitated the omission in the fifth and fifth mezzanine stories of all but four of the interior columns. In the first floor the 10-in. floor-beams about 4 ft. apart are carried by pairs of 15-in., 142-lb. I-beams connected to the cover plates of the columns so as to secure symmetrical loading. In the second floor both 10-in. and 12-in. I-beams are used and are carried by 15-in., 18-in., 20-in. and 24-in. I-beam girders and by plate girders with 24-in. webs and 6x6-in. flange angles. The third and fourth floors are similar and have their 10-in. beams carried by longitudinal plate girders 24 in. deep and about 36 ft. long and 16½ ft. apart. These girders are in the planes of partitions separating the cold storage rooms and their use permits the omission of alternate columns.

The fifth floor construction is similar to that of the third and fourth, except that the panel between the wall columns and the first row of interior columns on one side of the building is special and the floor-beams are at right angles to those in the other panels and are supported by single 20-in. I-beam girders. In the mezzanine story above the fifth floor the space between the wall columns and the first interior rows on two adjacent sides of the building is floored and has 10-in. transverse I-beams about 4 ft. apart supported by longitudinal plate girders 16½ ft. apart. The remaining two-thirds of the area of the building at this level is not floored, but there exists there a system of longitudinal and transverse lattice girders which carry intermediate horizontal I-beams affording an overhead support for the hoisting machinery and other apparatus of the killing floor. This arrangement also diminishes by one-half the unsupported lengths of the roof columns. The 12-in. longitudinal I-beams in the roof are carried by transverse plate girders 26 in. deep.

The outside walls are supported at every story, usually by single 12-in. I-beams connected to the columns on, or near the center lines, and provided where necessary with angle or plate shelves to give increased bearing for the brickwork. The size and position of the wall girders vary somewhat to correspond with the different sections of the wall. The street fronts are panelled by wide pilasters of brickwork. These are located on column centers and are carried by light beams, or channels bracketed out from the wall girders to form pocket-like extensions enclosing the columns.

The street fronts have a 4-ft. copper cornice supported by a steel cantilever framework projecting from the top of the parapet wall. The framework consists of two lines of 4x3-in. angles attached to brackets that are riveted to 8-in. horizontal top and bottom channels built into the brick walls.

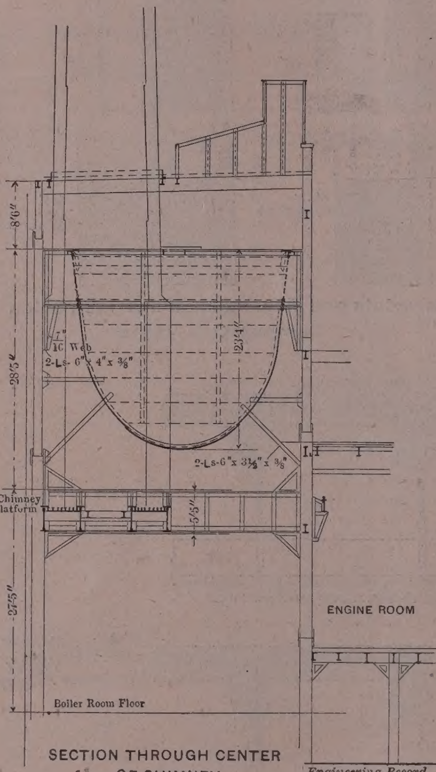
The cattle pens on the roof cover its total area, exclusive of skylights and pent houses, and are provided with galvanized iron roofs having Z-bar purlins and channel rafters supported by verticals, 8 ft. 4 in. high at the eaves, and about 13½ ft. high at the ridge. The verticals are pairs of 4x3-in. angles back to back, except at the corners where they are made with 6x6-in. angles. The upper ends are knee-braced to the rafters and cross beams in four directions by single 3x3-in. angles.

The transverse I-beams supporting the floor of the cattle runway leading from the ground to these pens at one side of the building are carried at one end by the wall columns, and at the other end are connected to a row of special outside columns proportioned for maximum loads of about 9,100 lb., and made with pairs of 5x5-in. angles riveted together back to back. The columns are spaced about 16½ ft. apart to correspond with those inside the building and are braced by the floor-beams and by six lines of horizontal I-beams and channels parallel to the wall of the building. The panels between these horizontal members and the columns are X-braced by single angles in three lines extending the full width of the building and alternate with rows of open panels.

A special feature of the floor construction is the provision made to continue the insulation between the cold storage rooms of the structure with minimum vertical interruption. For this reason the girders in the first, second, third, fourth and fifth floors were made double, as already mentioned and permit the insulated walls to be carried through the floors. These walls would require special framework to make them self-sustaining if supported only at the lower story. Such an element of enclosed steel work would be undesirable for the insulation and they were modified so as to be supported at each floor in such a manner as to make a nominal rather than a practical interruption to their continuity. Supports are provided for them by slabs of reinforced concrete 2 in. thick resting on shelf angles riveted to the inner faces of the twin girders as indicated in the detail. This affords direct support at every floor and enables the wall insulation to be carried down through the girders.

All of the floor girders are enclosed in cinder concrete which forms a fireproofing protection and is continuous with the floor slabs of reinforced cinder concrete of the Roebling type of construction. All of the floors and roof have at least 2 in. of cinder concrete filling over the floor slabs. The first floor has a 1¼-in. terazzo surface on this filling. In the roof a waterproof layer of cement and felt 1⅛ in. thick is applied to the filling above which there is a pavement of vitrified brick 2½ in. thick, thus providing a non-absorbent waterproof flooring for the cattle pens. The killing floor has waterproofed layers like that of the roof and above it a covering of large slabs of bluestone 3 in. thick. On that portion of the floor over the chill rooms and air cooler there is, however, a 3-in. layer of cork insulation provided between the bluestone and the floor slabs. From both of these floors as well as those of the second, third and fourth story there are suspended from the lower flanges of the I-beams a light I-beam framework carrying a ceiling of metal lath and cement plaster affording space for the ventilation and refrigerating ducts, all of which communicate with the rooms below through ceiling registers.

The floors of all the working corridors are finished with cement and have a cement sanitary cove base, which, with the bull nose corners, afford curved and filleted angles that prevent the accumulation of dirt and dust. Special provision is made at all angles of the floors and walls to exclude vermin with wire lath and steel rat stops, which construction was fully described in the previous article. None of the rooms are plastered, except the coolers, which have their walls finished with a mortar made of cement, magnesia, marble dust and sand plastered on the pressed cork, making a fireproof and waterproof finish. All other wall, floor and ceiling surfaces are of enamel brick or enamel tile or terazzo. The main stairway is of iron with "neverslip" steel steps, and is enclosed by fireproof brick walls. Exits are also provided at every story to the cattle runway, which is floored with steel plates and "neverslip" platforms and would serve as an ample fire escape.



Details of Bunker Construction.

The walls enclosing the refrigerator rooms are carefully insulated with air spaces and with non-conducting materials. The outside brick walls are in most cases furred with 3-in. hollow porous tiles. These tiles are covered with cement plaster, ½ in. thick and waterproofed, on which there is placed 3 in. of granulated cork pressed in sheets and cemented on in a 1-in. and a 2-in. layer, breaking all joints. Finally the surface of the insulation is plastered with patent magnesia plaster ⅝ in. thick, giving a total thickness of 7⅝ in. beyond the face of the brick wall.

The windows piercing these walls have copper-covered wooden frames and are provided with four thicknesses of glass separated about 1 in. The sash are not movable. The partitions between the refrigerating rooms are made with double 3-in. walls of insulating material having a 1-in. air space between them and a ½-in. coat of plaster on the outside. This construction is carried around the columns after the latter have been encased in cinder concrete, to which the insulating material is fixed without an intervening space. The large windows in the street fronts have cast iron frames and sash made in sections connected by bolts so as to provide easy removable strips securing the glass in position.

In order to select the best material for insulating the chill rooms and coolers and to determine its efficiency a series of comparative tests were made with four different types of insulating material. For this purpose four rectangular boxes 5½ ft. by 6 ft. by 6½ ft. outside dimensions were made of ⅞ in. yellow pine boards and each was lined with insulating materials and air spaces arranged so as to give total thicknesses of 5 to 8 in. In each box a 60 ft. coil of 2 in. pipe was placed and cold brine was circulated through it to reduce the inside temperature to 30° Fahr., the temperature of the room being maintained by stoves as close as possible to 70°. The air could not, however, be maintained at this temperature in the box lined with plaster block, probably because of sediment collected in the pipe coil. In each box there was provided a thermometer, an electric lamp and an electric fan.

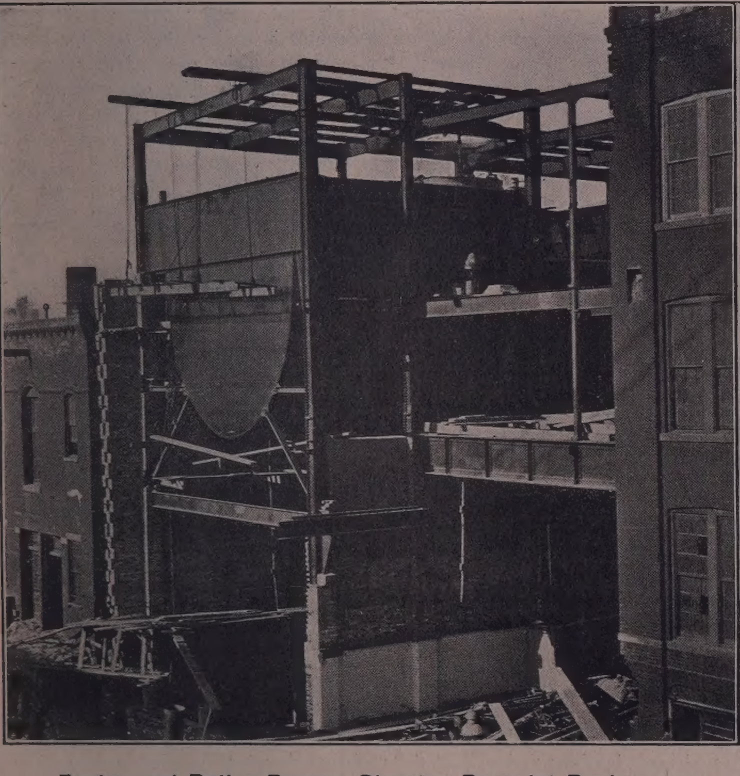
The test was commenced by maintaining the boxes at a temperature of 30 deg. for 60 hr., which was accomplished by regulating the flow of brine which was returned directly to the system without weighing. After the expiration of this time, records were taken for five consecutive periods of 6 hr. each, and the weight of brine; averaged temperatures of the box, of the room, of the entering brine and of exit brine; the specific heat of brine; the amount of brine used per hour; the rise in temperature of the brine; the heat units given up by the brine; the difference between the temperature in the box and the temperature of the room; heat units transmitted through each box per degree of difference between external and internal air per hour in B. t. u.; the number of square feet of insulation in each box; the heat units transmitted through one square foot of insulation per degree of difference in temperature between internal and external air per hour in B. t. u.; and the heat units transmitted through one square foot of insulation per degree of difference in temperature between internal and external air per 24 hr. in B. t. u. were tabulated. A moisture determination was made by placing a block 12 in. high of each insulating material in water 1 in. deep and measuring the absorption. From a comparison of results it was decided that Specimen No. 2, the cork slab manufactured by the Nonpareil Cork Co., was most satisfactory, and it was therefore adopted.

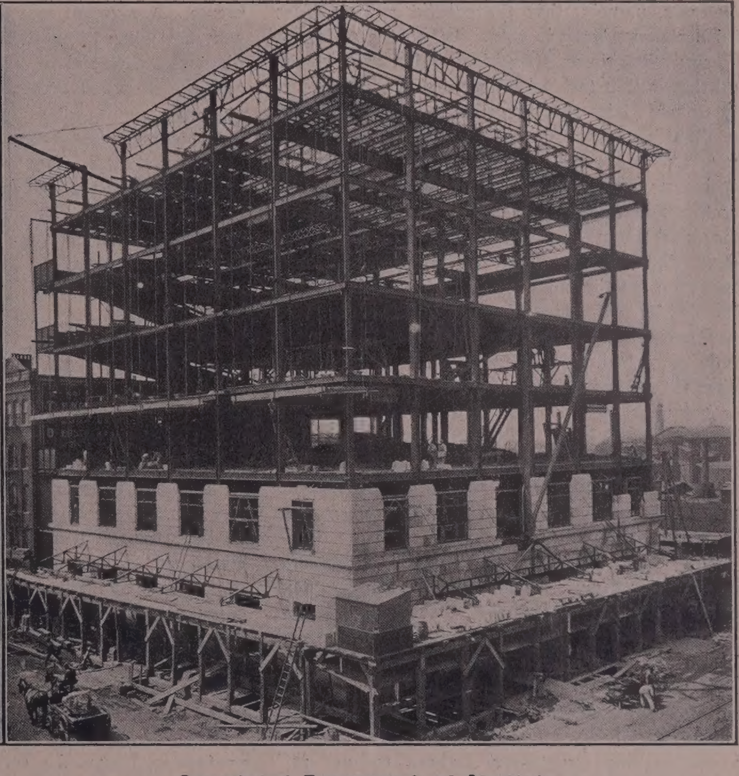
The 99-73-ft., three-story power house about 60 ft. high above the street level, is adjacent to the abattoir and is divided by a transverse partition into a boiler room and a pump room besides which there is a large cold storage vault and weighing hopper under the sidewalk. The entire height of the boiler room is occupied by a single story and it contains four 400-h.-p. Stirling water-tube boilers arranged in pairs. Above each pair of boilers there is a 400-ton Berquist steel coal bunker, one of which has a space reserved for the storage of ashes. The steel framework is supported by fifteen main columns and five secondary cast-iron columns all arranged from 10 to 17 ft. apart in four longitudinal rows about 21½ and 33 ft. apart. The riveted columns have closed rectangular cross sections made with pairs of channels and cover plates and receive the transverse I-beams up to 20 in. in depth and plate girders carrying the longitudinal floor-beams from 6 to 15 in. in depth.

All main columns are seated with extended bases on I-beam grillages having short concrete piers carried down to solid rock as described for the main building. The sidewalk is carried over the vault 15 ft. wide by 12 in. I-beams about

4 ft. apart which are supported at the inner ends by the lower masonry and at the outer ends are carried by vertical I-beams built in the concrete retaining wall and connected at the upper ends by horizontal 15-in. channels, flanges down. The vertical I-beams are proportioned to resist an external horizontal pressure of 5,700 lb. per linear foot, applied two-thirds of the distance from the top to bottom. The boilers are supported directly from the surface of the ground and occupy a space extending from the basement to above the first floor.

The space over the boilers is occupied by coal bunkers, details of which are shown in the accompanying illustrations, and by an Alphons Custodis chimney 15½ ft. in diameter at the base and 152 ft. in total height. This chimney weighs about 475 tons and is built on a grillage of rails covering a plate-girder platform in the second tier. This platform consists of 15-in. I-beams about 2 ft. apart, and from 4 to 6 ft. in length, which are web-connected to four transverse plate girders, 36 in. deep and 17 ft. 2 in. long, supported by two main longitudinal girders, 60 in. deep and nearly 33 ft. long, connected directly to four of the main columns of the building. These girders have webs ¾ in. thick reinforced at the ends nearest the chimney platform to a total thickness of 1 1/16 in., and have flanges each made with two 8x8x⅞-in. angles, and three 18x¾-in. cover plates.


Engine and Boiler Rooms, Showing Berquist Bunker.


Completed Framework of Abattoir.

The basement floor of the pump room is somewhat lower than the boiler room floor, and on it are located oil extractors, condenser pumps, heaters, receivers, fans and other miscellaneous plant. The first story is occupied by the engines, generators and ammonia compressors, and is served by a 15-ton hand-power traveling crane which commands the entire area. The second floor of the boiler room is reserved for general purposes, and the third floor is used for the oil presses required in the fat-rendering plant. The floor surface is of wood supported on steel girders and columns and is thoroughly calked and pitched to a gutter. The ammonia condensers for the compressors and air cooling systems are located on the roof, which in that place only is of fireproof construction.

The three heavy engines aggregating 1,000 kw. and the two ammonia compressors aggregating 250 tons are seated on the first floor of the engine room which is so constructed as to absorb vibrations and secure great rigidity. Their beds are bolted to intermediate pairs of channels, web-connected to main girders made with pairs of 15-in. channels, back to back. Web plates 4 ft. deep are riveted to the ends of the channels and extend across the webs of the two channel columns with which they form a connection and at the same time serve as solid knee-braces. None of the interior basement columns are continued through the first story, but the upper story interior columns are carried on second-story girders, an arrangement which maintains the first story entirely clear of all obstructions and provides for the travel of the girder crane.

The third tier of beams in the engine house consists of longitudinal and transverse I-beams from 8 to 20 in. in depth on the lines of the columns only. These act as braces and do not at present carry any floor slabs, the second story reaching continuously through them to the roof. At the ends of the building the roof beams like those in the floors are carried by the brick walls. On the sides and in the interior they are carried by the columns and the longitudinal row of cast-iron columns provided in the center line of the engine room in the second and third stories to carry the beams. The total weight of steel in the power house is about 838,000 lb., and in the abattoir building is about 2,860,000 lb. The designs were made and the construction was supervised by Horgan & Slattery, architects, for whom Mr. A. Rodriguez is chief engineer, and Mr. E. T. Macdonald is chief assistant architect. Mr. Jacob A. Zimmermann was the masonry contractor. The structural steelwork was fabricated and erected by J. B. & J. M. Cornell Co. The insulation tests were conducted by Prof. F. L. Pryor, of Stevens Institute of Technology.

Rapid Trestle Reconstruction was recently carried on at Galveston, Texas, when 400 ft. of the long railroad trestle extending from the mainland to the city was destroyed by fire. Construction forces and materials were immediately started at work and the trestle was sufficiently repaired by midnight of the same day so traffic could be resumed.

Protective Coatings for Iron and Steel.

A paper read before the American Society for Testing Materials by Mr. Arthur B. Harrison.

Protective coatings should be divided into three classes, namely: (1) linseed oil paints; (2) varnish and enamel paints; (3) carbon coatings, using solvents, that dry by evaporation. The all-important factor in protective coatings for the preservation of steel is the efficiency, under the actual conditions of exposure as they exist, and not as they should be or as we would like to have them. A vast amount of very valuable information has been given as to how steel should be prepared for coating. We may as well face the conditions as they are in actual practice, knowing as we do that steel is seldom or never properly prepared for coating, and never will be; mill scale, rust, dampness, and even dirt being more frequently covered up than removed before the coating is applied.

For a great many years this question has occupied to a great extent the minds of the leading engineers of the world, and yet up to the present time it has resulted in little but theorizing and temporizing, and no definite conclusions have been arrived at, except that all coatings seem to fail in time, and it has come down to one fact, that as far as protecting the steel is concerned, the only thing to be done is to accept the conditions as they exist and make the best of a rather bad state of affairs.

It seems to be the general concensus of opinion that there are no coatings that will protect steel against corrosion under all conditions, and yet, sooner or later the coating that will serve the purpose best, under normal conditions will be recognized as the standard for this particular work.

It was stated by the late Edward Atkinson, of Boston, some years ago that any coating that contained linseed oil and dried by oxidation tended to corrode steel. It seems to me that this fact should be absolutely determined, and if after experiments, tests, and chemical analysis this proves to be a fact, it should be so stated, in order that consulting steel engineers can turn their minds into other channels; and upon the most thorough investigation in the laboratory and in the field, and under all possible conditions, find a material that when applied to steel will protect it better than any other material known. If it is a fact that linseed oil, or a coating that contains linseed oil as a vehicle, lacks the efficiency and permanency claimed for it, it should be so determined and announced.

This is an age of scientific progress. Engineering problems should be solved by exact science, and nothing should prevent us from arriving at the truth. In the past, certain weaknesses have been claimed and have developed along the line of carbon coatings; but if comparative results were placed in parallel columns, there is no doubt that the efficiency of carbon coatings would be found far in excess of that of paints containing linseed oil as a vehicle for a protective coating. I myself know that up to the present time there are certain inherent weaknesses in carbon coatings and these weaknesses are due to the following reasons:

There is a tendency in carbon coatings not to oxidize, for the simple reason that there is nothing in the material, generally, to oxidize. There is one reason advanced by some authorities, who seem to give great weight to it and consider it a weakness, namely, that the carbon coating fades and becomes a gray in color, due to the action of the sun. But there is one fact which they forget, and that is that the manufacturers of carbon coating do not claim that the material is a paint; per se, these carbon mixtures are not put upon the market to serve the purpose of a paint, but as a coating to protect steel. There is one great difference, and that is, that one is a paint used for color, and the other is used simply as a protective agent; and I believe that in future we should make this distinction and work on this theory alone. An oil paint upon wood serves two purposes—first, as a colored surface, and, secondly, as a protective medium, and its failure in either direction would indicate its inefficiency. A coating upon steel, on the other hand, should be simply and solely a protective coating, and the permanency of its color is a trivial and insignificant matter. This theory we should pursue, no matter what the result might be, or whom the result might hurt.

While I am not a chemist, I am to all intents and purposes a practical man, endeavoring to deal with a practical subject, and some very valuable literature has been written by Newman, Wood and Dr. Sabin, all of which has been extremely advantageous, but no matter if we had a library the size of the Tilden, filled with literature upon the subject, we have had enough experience to know, to use a slang expression, "where we are at," and it comes right down to the simple question, that steel rusts, and the point is, to prevent it. We need no microscopic slides on a screen to prove that to us; but it seems to me that what the engineering world desires to know is this—that steel is received in a rusty condition, and such being the case, what is the best material to apply to the steel, in its normal conditions, to arrest and prevent further rust. It appears to me that it is only a question of a comparatively short time before this problem will assume a far more satisfactory phase in the scientific world, as I believe that the solution of this question has been hampered, to a great extent, by endeavoring to settle it by depending upon chemical reactions and mechanical mixtures. It is my opinion, further, that we will go back to nature,—that we will be obliged to depend upon a natural product.

Much scientific, technical and practical data has been given as to pigments, oils, etc.; how pigments should be pulverized to a fineness known as air-floated, ground in pure linseed oil, etc. Whereas, in practice, we find that of the pigments used in paints a great proportion would not go through a sixty-mesh sieve, much less being air-floated. Result, inefficiency!

There is no such commodity on the market as pure linseed oil. Other seed-bearing plants grow along with the flax, and all the seed are gathered and pressed together. This, however, is not the only adulteration to which linseed oil is subject. Let us take, for instance, red lead which has been largely used as a preservative coating for steel. In order to obtain the best results and the full efficiency of this pigment, it should be thoroughly mixed with linseed oil and kept well stirred while being applied, small quantities only being mixed at one time. This, we know, is seldom or never done. I have seen some specifications from engineers calling for one helper to stir the red lead for every two brushmen. Other specifications call for the pot of red lead to be stirred between brushfuls when being applied by the painter. This, we also know, is seldom, if ever, done.

The same applies to any paint in which the pigment is much heavier than the vehicle, the efficiency being lessened or lost in the application, in which the poor quality and kind of brush used is an important factor; wall brushes and cheap paint brushes being too prevalent.

In mixing paints, I think too little attention is given by the manufacturer to compounding pigments. A pigment may be absolutely inert in itself, but when brought in combination with other pigments, chemical or galvanic action may begin, and the so-called protective paint becomes a destructive agent when applied to the metal.

A memorandum from an advertisement of one of the producers is apropos here. Many a stately building is built nowadays with the germs of decay imbedded in its very skeleton. Even the coatings put on the steel framework to protect it, are often themselves producers or starters of decay. The importance of the steel frame of large buildings is so vital that owner and architect alike should be willing to go to any length to assure themselves of its proper preservation.

At our mill on the water-front in Brooklyn, located in the heart of the chemical district, in addition to the atmospheric conditions (being probably the most severe of any part of New York), we add our little quota to the numerous destructive gases from our battery of calcining kettles; in fact, a large portion of the mill is constantly enveloped in vapor heavily charged with sulphuric-acid gas from our kettles. The result on corrugated steel roof, sheathing, and in fact any other steel, was simply appalling, as the steel was eaten away in a very short time. We were unable to buy a paint that would protect this metal under prevailing conditions, even for a few months. As it was a case of self-preservation and protection, I started a series of investigations and tests to procure a coating that would protect. As man and science seemed to have failed, I procured samples of bitumen, hydro-carbon and asphaltum from all over the world. After hard work, both practical and technical, and scores of tests covering a period of years, in laboratory and in field, I selected one of these products which seemed to me to have the necessary qualifications to protect steel against corrosion under the most severe conditions.

This material is found in the West and resembles in composition and in many of its characteristics the mineral ozokenite. It is unique among deposits of mineral wax in its adaptability to the formation of a tough, impervious and extremely adhesive coating, with a high degree of elasticity; it lacks the brittleness of many of these deposits and is distinguished from all deposits of what is commonly known as asphalt, by the qualifications just enumerated.

By a special process of refining, this material can be prepared for the market with a very small percentage of residuum, grit and rock, and at the same time valuable characteristics are preserved.

It is my belief that no coating will protect steel against corrosion which is not absolutely waterproof, in addition to which it should have the following properties: The bond between the metal and the coating should be perfect. It should remain elastic under all conditions of temperature, and after it has been applied for years. It should be impervious to acids and alkalies, and should resist the action of all gases. The material should be absolutely inert, and a nonconductor of electricity.

Some authorities state that corrosion of steel is due solely to electrolytic action. I believe that corrosion is greatly accelerated by the action of the electrolite, which, as we know, consists of moisture in any form, and must be acidulated or saline. It is absolutely necessary, therefore, for the protection of ferric bodies that we require a coating which will prevent this electrolite or moisture from coming in contact with the steel. Many oil paints which contain oxide or carbon as a pigment are good conductors of electricity, and a paint having such a conductor among its ingredients is much less likely to protect against electrolytic action.

Moist air tends to impregnate and saturate an oil paint coating on steel more thoroughly than direct immersion, and after the humidity has been dispelled, the pigment in such a coating retains the moisture and holds it against the steel for many hours. Having finally dried out, it leaves a more or less porous coating, exposing the metal to all the other oxidizing elements. I should like to give to this Society the benefit of some of my experiments with this material on steel surfaces which were coated with rust to the thickness of from 1-64 to 1-16 of an inch. As you know, a large portion of this rust scale is moisture. Mr. Wood says: "Rust begets rust, and unless rust is removed from ferric bodies, corrosion will continue even though the surface be covered with a good paint." After coating the surface on which this rust scale was, I allowed the coating to remain for thirty days, and then removed the scale with a putty knife, and, much to my surprise, found there was no moisture left in this scale. My test to ascertain this was made by dropping pieces of this scale into boiling wax which was at a temperature of over 350 deg. Fahr. The absence of bubbles proved beyond all question of doubt that there was no moisture present. Had there been, there would have been very many bubbles.

Another experiment was to coat clean, wet iron castings with this material, first rubbing off the surplus moisture with a rag and immediately thereafter applying the coating. An examination of these coatings, months afterwards, proved that they were absolutely free from rust. Had the moisture remained on the surface of the iron, corrosion must have been the result.

My theory is that this material has such a phenomenal bond and affinity with all ferric bodies that it displaces and takes the place of moisture, and that the moisture, being driven out, comes to the surface with the solvent and evaporates. This same theory applies to the rust scale, as on examining pieces of this scale I found they were saturated through and through with the material, and where the scale was thin, had been actually cemented to the surface of the steel.

In practical field tests on this same order, one of the great corporations of the country coated some twenty pumps. These pumps were under the bed of a salt river, and were used for keeping the tunnel clear of leakage. The pumps being kept constantly in action, were much cooler than the atmosphere in the tunnel, and condensation was therefore very great; the pumps were actually running with water all the time. These pumps were coated with this material, it requiring two men for the operation, one to rub the water off the pump with a rag, while the brush man followed him, and applied the coating. The coating set and became hard after an hour, and remained on these pumps, protecting them against further corrosion, for a period of one year. How much longer this coating will protect, under these severe conditions, I cannot say, as the pumps were only coated about a year ago.

In addition, in field tests I have in mind a number of instances where the results have been equally satisfactory and gratifying, both to myself and to the interested parties, in the work done in paper and pulp mills, where nothing has stood before; in tunnels where the blast from the engine and gases were so destructive to all metals; in train sheds, round-houses and overhead bridges. In none of this practical field work, or field tests, has the material fallen down.

One thing more. I found many corporations and municipalities refused to use a true carbon coating, even though in efficiency it proved to be the best preservative coating. This, on account of its color, black, they being unable to procure an oil paint of lighter shade that could be applied as a finish coat, on account of the color striking through.

After reading the statement made by the late Edward Atkinson, I took up, first as a pastime, and secondly, as a serious proposition, the question of the oxidation of linseed oil, having made up my mind that the lift of a paint depended upon the life of the oil. The results were very gratifying because I ascertained by a long series of tests in the laboratory and in the field, that I could take linseed oil, and by treating it with certain processes I could prolong the life of the oil—I will not say indefinitely—but prolong the life of the linseed oil, and its efficiency, to such an extent that paint made with it as a vehicle would resist the action of the strongest paint removers, gas drip, benzol, etc., and that a paint made with this treated oil would go over a carbon coating perfectly, without the color striking through. The co-efficients of expansion and contraction seem to be identical, so that we are now able to furnish nature's pure carbon coating as a preservative coating on top of which an oil paint can be applied, acting as a decorative coating and at the same time protecting the carbon coating from the rays of the sun, which seem to be its only enemy in nature.

It has taken the technical world some years before it has allowed itself to recognize the great efficiency of oxide of zinc. Field results have proven the claims advanced for this material years ago, and I am inclined to prophesy that, upon investigation, carbon coatings which dry by evaporation, will finally be recognized as standard.

I desire to incorporate the following suggestions: That the society should endeavor to have tests made on steel cars of the various systems, in order that the efficiency of coatings for cars may be determined under severe conditions. And undoubtedly if this recommendation is adopted, arrangements with the different systems can be brought about. If members of the Society are desirous of making their own tests for the purpose of proving the foregoing statements, I will willingly furnish them samples of this coating. In this coating there is no difference between a sample and the standard article, as it is nature's product, and I would be unable to furnish a better sample than the standard article, no matter how I tried.

Experience with Tall Brick Chimneys in the recent earthquake at San Francisco indicates that they are liable to serious damage or destruction from seismic disturbances, as practically all of the tall stacks of power plants in the earthquake zone were destroyed or damaged badly. It is also worthy of note that in many cases the stack was the only portion of the plant to be affected. This condition will very probably prove a factor in influencing the employment of other materials than brick masonry for stacks, such as some type of reinforced-concrete construction, or the use of short steel stacks and mechanical draft equipment.

The East River Tunnels for the New York City Terminus of the Pennsylvania and Long Island Railroads.

The structure now being built to connect the Long Island Railroads in the Borough of Queens with the great new terminal station at 32nd and 33rd Sts., and Tenth and Eleventh Aves., New York, is known as the Pennsylvania, New York and Long Island Railroad, and has a total length of about 16,000 ft., which for construction purposes is divided into two sections, one extending from the portal at Thompson Ave., Long Island City, to the First Ave. shaft, New York, and the second from this point about one mile to the terminal station. The first section includes a length of about 3,900 ft. under the East River between the permanent shafts, and about 2,000 ft. eastward from the permanent shafts in Long Island City, and consists of four parallel lines of cast-iron circular tubes 23 ft. in external diameter, lined with concrete and each carrying a single track at a maximum depth of about 90 ft. below high water. This section is being constructed by Pearson & Sons, Inc., contractors.

The contract for the Manhattan Island section was awarded to the United Engineering & Contracting Co. and work on it is progressing rapidly in six headings for the two-track and three-track concrete lined structures driven westward from shafts at First Ave. and in both directions from shafts at Madison Ave. This work is all in solid rock, and is being done under atmospheric pressure. The method is normally that of a full width top heading followed by a narrower single bench which is eventually widened to the required dimensions, but the details of excavation have been been somewhat modified to conform with special conditions at different points.

One of the features of this construction is the elimination of steam power at the Madison Ave. shaft, where the compressors furnishing compressed air for the rock drills, pumps and other apparatus are operated by General Electric Company's motors, and the spoil is hauled in the tunnels by General Electric locomotives and hoisted by elevators operated by electricity.

The general features of the cast-iron lined tubes and of the concrete tunnels in the land sections were illustrated and described in The Engineering Record of Oct. 10 and 17, 1903, where a description was also published of the steel caissons for the main shafts in Long Island City and at First Ave., New York. These shafts, about 150 ft. apart transversely, are about 40 ft. wide and 74 ft. long and are sunk to depths of about 78 and 88 ft. In each of them two shields, eight in all, about 18 ft. long and weighing 542,000 lbs., were each erected and driven in opposite directions towards the center of the river. These shields, are each operated by twenty-seven 9-in. hydraulic jacks operated under a pressure of 6,000 lbs. per sq. in., and developing a maximum aggregate force of 10,360,000 lbs. to advance the shield. They are of special improved construction similar to that used for the Blackwall tunnel under the Thames at London, and are each provided with movable shutters in the face so that the entire heading may be closed and excavation made through adjustable openings which limit the apertures in such a way as to avoid danger of serious blow-outs through the soft material. Excavation from the New York side has now reached nearly the maximum depth and is being carried on under air pressure of 32 to 35 lbs. above the normal, which pressure is furnished by a large compressor plant.

From the permanent shafts on the Long Island side excavation westward has just been commenced in two southerly lines, and is about to be commenced in the two northerly lines. For them a compressor plant is provided similar to that on the New York side.

A third shaft has been sunk on this division near the Long Island portal and is of such dimensions as to receive all four of the single-track tunnels which were started from its foot in both directions, making a total of eight headings commenced there before the main shafts in Long Island City were completed so as to expedite the work. These headings were commenced under atmospheric pressure and were driven for some distance through the rock. About 1,600 ft. west of the shaft conditions changed and it became necessary to provide pneumatic pressure in the headings on the river side of the shaft where two shields have been erected similar to those for use under the river, but of considerably lighter construction. As these shields do not have a great distance to go, there will be sufficient time for them to complete the first two tunnels and be re-erected for the construction of the other tunnels before the river tunnels are completed. At the New York end work is suspended in two of the East River tunnel headings and is being prosecuted in the other two. There are therefore, in all, ten shields now in operation, or nearly completed, and work is being carried on in eight headings with a total force of about 500 sandhogs working in a maximum pressure of 32 to 35 lbs., and the shields advance at different rates in the different tubes and have made as high an average as two rings or 5 ft. in 24 hours, and each has as high a maximum as three rings or 7½ ft. in the same time. Air pressure was first put on in November, last, and three of the headings have advanced about 300 ft. beyond the New York bulkhead and two others have advanced about 1,500 ft. from the Long Island shaft, thus making together nearly one-third of the entire length of the tunnels and affording reasonable expectation of the completion of the work in contract time in the fall of 1908.

The character of the soil and position of rock has coincided very closely with the indications of the preliminary test borings. The shield excavation of the New York headings is now being made wholly in quicksand which has a depth of only about 15 ft. above the top of the tunnel, nearly the minimum roof thickness. The material here is so soft and weak that it is difficult to adjust the pressure over the high face of the heading. When the pressure is heavy enough to balance the hydrostatic head at the bottom of the shield it is so great as to cause a blow-out at the top. If it is only great enough to balance the top pressure it will not keep out the water at the bottom, therefore it is made to correspond approximately with the pressure at a point a little below the center of the shield. This serves to dry the quicksand at the top of the shield so that it is comparatively hard and firm, while at the bottom it is very wet and soft. Slight variations occur frequently and as is especially common in such large headings in soft material there are occasional blow-outs, which, together with the inevitable leakage through the shutters and under the tail piece of the shield, cause a loss of air, which is not considered excessive when less than 5,000 cu. ft. per minute, an amount which is easily provided for by the compressors. Occasional leakages are in excess of this amount and cause some difficulty and delay, but no serious accidents have resulted from them except in one case where the blow-out was followed by a considerable inflow of water, and two of four men in the shield were so firmly stuck in the tenacious mud that they were suffocated before they could make their escape. No other fatalities have occurred in the tunnel work which were attributable to blow-outs.

Careful provision is made for the safety and comfort of the tunnel men. They are worked two 3-hour shifts, with a 3-hour interval between shifts, making 6 hours for a full day's work. They are lowered and hoisted in the shafts in electrically operated elevators and enter through the ordinary locks, which are provided with pressure gauges and have clocks by which the rate of speed in exit may be regulated. This is fixed at about 20 minutes for the present pressure, and as soon as the men emerge they enter a heated room equipped with a lavatory, shower baths, and iron lockers for their clothes and valuables. Adjacent there is a reading and lounging room, where they are encouraged to spend the interval between shifts, and are supplied with unlimited quantities of excellent hot coffee. Great care is taken to exclude weak or diseased men, and none are permitted to enter the tunnel without passing a rigid medical examination and receiving a brass check, which they must present each time they enter. Physicians are always in attendance day and night, and prompt treatment is thus secured in case of any accident or for caisson disease. Considering the amount of pressure, the number of men and the magnitude and duration of the work it is considered that the number of deaths due to the pressure is below the average on similar works, only about ½ of 1 per cent. of the men employed having died from caisson disease. Many of the men are subject to light attacks of the bends, which principally amount to severe pains in the joints, and usually pass off without serious trouble. When the men report these immediately to the physician they are generally treated by being put temporarily under pressure. For this purpose special hospital chambers are provided. Each of them consists of a steel cylinder 7 ft. in diameter and about 10 ft. long, contains two beds with wire mattresses and is fitted with air circulation apparatus, thermometers, clock and a telephone, and communicates with the open air through a smaller chamber which serves as a lock to permit entering or leaving the hospital while it is occupied by a patient. The patient is taken into the hospital by the physician and the pressure is quickly admitted up to the intensity of that in the tunnel. It is then very gradually reduced, often requiring an hour and one-half to bring it down to normal. This generally suffices to cure the patient; if it does not wholly relieve him it usually benefits him and he is further treated with electricity and by the application of special ointments to provide a slight counter irritation. There are in all six of these hospital locks, and the results obtained are considered very beneficial and satisfactory. Careful provision is also made for the other workmen employed by the contractors, and dressing rooms, lockers, baths and other conveniences are provided for them.

In order to promote the best conditions for working under compressed air great care is taken to ventilate the tunnel, and the quality of the air is determined by analyses made from samples collected daily at different levels of the tunnel from every point at which the men are at work, including the three platforms of the shield. By these tests the quality of the air is constantly checked and its purity is maintained so that the amount of carbonic acid gas contained in it is much less than the 3 per cent., which is ordinarily admissible. A supply of at least 10,000 cu. ft. per hour of fresh air is provided for each man working in the tunnel.

When the quantity of air escaping from the tunnel becomes excessive, clay is dumped into the river bed above and serves as a blanket to seal the leakage. This clay is secured from the bed of the Hudson River at Haverstraw, N. Y., where about 10,000 cu. yds. a week are dredged from a depth of 40 ft. and are shipped to the tunnel site in 600-yd. bottom-dump barges. One of these is always in attendance, and when the air escapes too freely through the river bed the barge is towed out to the required position, located by intersecting lines, and the clay is dumped. Until recently the amount of clay allowed has not been fully sufficient, but a permit has been secured which will enable the contractors to fill in clay for a length of 350 ft. up to a distance of 27 ft. below water level; thus providing for a maximum fill of 20 or 30 ft. above the finished portion of the tunnel roof, an amount which is considered ample to provide the necessary weight and tightness. The same clay is also used in considerable quantity for plastering over the joints of the shield and shutters where the air is most likely to escape.

At the inception of this work it was realized that its magnitude and the local conditions made it of great importance and difficulty and a very careful and comprehensive study was made of the conditions, requirements and best methods for its construction. Among the different methods proposed by engineers, and described in The Engineering Record for March 21, 1903, it will be remembered that Charles Sooysmith recommended the use of the freezing process. It is not now proposed to use that process for this tunnel, but in order to determine its merits and its possible availability for future tunnels contemplated under the charter of this company, a series of investigations are being made by the company under the direction of Mr. E. L. Abbott. A pilot tunnel 7 ft. in diameter with its roof at about the level of the roof of the main tunnel, has been driven a short distance under the East River from the bottom of a 16-ft. steel shaft, near the foot of 35th St., and a section of it has been provided with pipes parallel to the axis and close to the iron shell. Through these pipes a refrigerating solution has been circulated at a temperature of about 34 deg. Fahr. below zero. It is proposed by this means to freeze a cylinder about 35 ft. in diameter, which would provide a wall of ice 6 ft. thick on every side of a concentric tunnel 23 ft. in diameter, excavated from the pilot tunnel. This experiment is still in progress, and up to date has cost about $100,000.

Mr. Alfred Noble is the chief engineer, Mr. C. L. Harrison principal assistant, Messrs. Francis Mason, George Leighton, James H. Brace and S. H. Woodward, resident engineers. Mr. E. W. Moir is the vice-president of the Pearson & Sons, Inc., contractors, and Mr. Henry Japp, managing director.

Recent Work on the Blackwell's Island Bridge.

The erection of the Blackwell's Island bridge across the East River in New York was resumed a few weeks ago after work on it had been suspended since Jan. 1 last on account of a strike due to a demand by the labor union for increased wages in the Metropolitan district. The work is now being carried on with a force of about 160 non-union workmen, which force will be increased as requirements demand. The 630-ft. island span has been erected up to the middle point of the trusses, thus including all of both floors except the buckle plates and representing about 6,600 tons of steel. Traveler No. 1 has reached pier No. 3, and has finished its work for this span; traveler No. 2 has been erected, and will be ready within a week to complete the erection of the span by assembling the other parts of the trusses and the top lateral and sway brace system. The materials for this work will be delivered to the middle of the span from the adjacent storage yard, when they will be hoisted and taken to the traveler on material tracks now being laid for the purpose on the upper deck. About 8,000 tons of material have been received and stored on the island and probably 15,000 tons are ready for shipment from the shops. All of the bottom chords for the bridge and most of the members for the cantilever arms adjacent to the island span have been fabricated so that all is in readiness for uninterrupted erection, and it is hoped that the work will progress rapidly in the future. With the exception of the 1,800-ft. span of the Quebec bridge which, however, has a smaller capacity, this bridge will contain the longest truss spans in America, and, judged by its mass and capacity, will be the largest bridge in the world. It is so well proportioned that the incomplete island span now visible from New York City does not appear of extraordinary dimensions, and it is impossible to realize the great size of the pieces of diagonal members over 100 ft. long, or of the 60-ton derricks which handle them until actually arriving on the structure.

It will be remembered that the two anchor arms and the island span are to be erected on steel falsework about 120 ft. high, consisting of double transverse bents braced together to form towers and carrying heavy top girders and steel platforms to receive the camber jacks. The falsework for the island span weighs about 1,700 tons, and is assembled in the field with bolts instead of rivets to facilitate the removal and re-erection on shore for the anchor arms. The erection of the falsework was commenced in January, 1905, and after its completion the erection of the permanent superstructure was considerably delayed by waiting for the large cast-steel pedestals under the pier posts.

After they were put in place the lower halves of the trusses and the upper and lower floors were erected by steel traveler No. 1, a simple traveling platform with two 65-ton 85-ft. derrick booms. This traveler and rigging weighs about 300 tons, and commenced work in the last of October, 1905. Traveler No. 2 is one of a pair which will erect the remaining 5,000,000 lbs. of steel in this span, and will afterwards erect the cantilever arms. It is a Z-shape steel tower, similar in outline to those used for the Monongahela and Mingo bridges, and for the Quebec bridge, all of which have been described in these columns. It is of a unique type, developed for the construction of these greatest cantilever spans, and consists substantially of a 36 x 40-ft. steel tower, 124 ft. high with an extended base and a 63-ft. top overhang from which will be suspended a large number of tackles of 5 to 40 tons capacity, operated by one special six-spool and one standard eight-spool hoisting engine. It will have a capacity of about 80 tons, and even this great strength will only enable it to handle the halves of the maximum truss members which have been designed to be shipped and erected in halves and longitudinally field riveted together. The traveler, which moves inside the trusses and when full rigged will weigh about 550 tons, requires a complement of about 60 men to operate it. Great care was taken in its design and construction and some of its members are quite elaborate. This is especially true of the massive forward trucks made with systems of pin-connected girders and pedestals to receive the great loads from the forward columns of the traveler and distribute them equally on the eight wheels.

Comparative Tests of Alcohol and Gasoline recently made in internal combustion engines indicate a very high operating economy from alcohol, though it has only about 70 per cent. of the thermal value of gasoline. The superior economy with alcohol, which has been put as high as 20 per cent., is due in part to the higher pre-ignition compression. This showing is of considerable importance in view of the removal next year of the internal revenue tax on denatured alcohol, which will, it is said, permit the commercial product to be sold for about the present price of gasoline. It is generally considered that alcohol may be used in standard gasoline engines with some slight modifications in the carbureter or vaporizing devices.

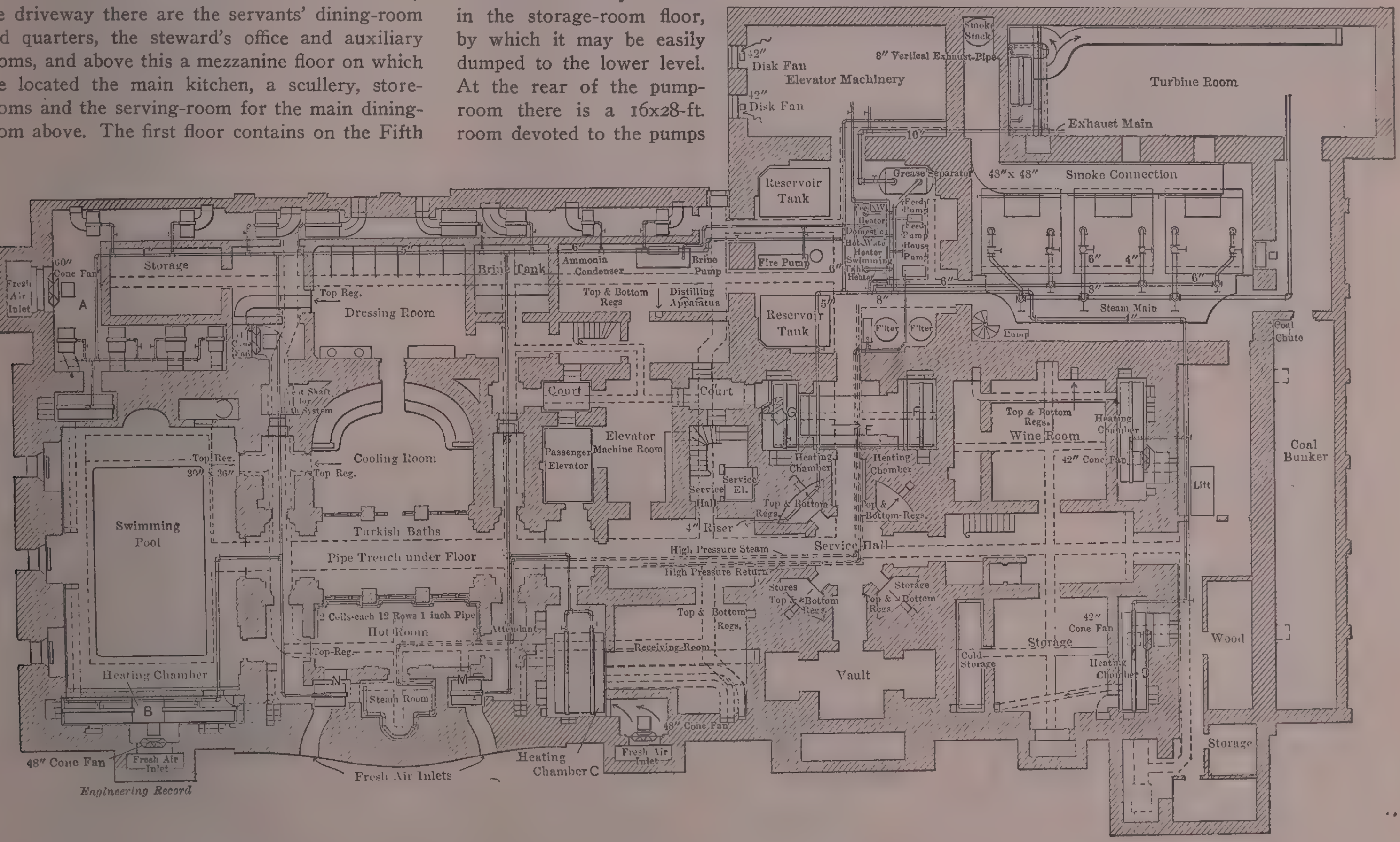
Mechanical Equipment of the New Residence of Senator Clark in New York.

The new residence of Senator W. A. Clark, now approaching completion at Fifth Ave. and 77th St., New York, is one of the most elaborate of New York's fine mansions. It is a seven-story and basement stone structure and occupies an irregular shaped plot with a front of 77 ft. on Fifth Ave., one of 215 ft. on 77th St. and a width of 105 ft. at the rear, where a driveway and court divide the building into two portions. Massive stone construction, with steel and concrete floors, has been used, and the walls are faced with granite to the fourth floor level, a height of 66 ft., above which there is a mansard roof covering the three upper floors, a height of 32 ft.

The ground floor contains the main entrance from 77th St., the carriage entrance, a reception room, a private office and a library at the front and a billiard and smoking-room and servants rooms in the rear; in the portion divided off by the driveway there are the servants' dining-room and quarters, the steward's office and auxiliary rooms, and above this a mezzanine floor on which are located the main kitchen, a scullery, storerooms and the serving-room for the main dining-room above. The first floor contains on the Fifth Ave. front a 25x45-ft. grand salon, with a petit salon, morning-room and conservatory adjoining, a 22x95-ft. music room at the rear, a sculpture hall and a picture gallery in the portion of the building over the entrance driveway, and the main dining-room. In the picture gallery, which is 25 ft. high in the clear, there is to be an organ in a gallery extending across the southern end, and opening off the rear end of the main picture gallery, there is in a rear wing a smaller picture gallery, with a faience gallery underneath. The second floor contains the principal bedrooms and boudoirs, a sitting-room at the Fifth Ave. front corner, a breakfast-room above the dining-room, and a large library at the rear over the music room. The third and fourth floors contain guests' rooms, a reception hall, a salon, a dining-room and a nursery. The fifth floor contains the housekeeper's quarters, a servants' sitting-room, sixteen servant's bedrooms and a trunk storage room, while on the sixth floor there are ten additional servants' bedrooms and the laundry for the residence service. There are eighteen complete bathrooms in all, thirteen for owners' and guests' purposes and the remaining five for the servants.

The basement, which underlies the entire site including court areas and driveways, is for the greater part devoted to the mechanical equipment. At the front end there is a Turkish bath and swimming pool, and at one side a series of storerooms, refrigerators and other facilities for kitchen supplies. The power plant proper occupies the rear corner of the basement, consisting of a 25-x40-ft. boiler room underneath the main court and driveway, a 16x50-ft. turbine room in the extreme corner beneath the faience gallery, and a pump room, 28 ft. square, beneath the driveway vestibule. All rooms of the basement with the exception of the Turkish bath have their walls and most of the ceilings lined with white enameled brick. The coal storage bunker for the plant occupies a 10x60-ft. space beneath the rear driveway and has a capacity for about 75 tons. The coal is very conveniently handled to the boiler room by a chute in the storage-room floor, by which it may be easily dumped to the lower level. At the rear of the pump-room there is a 16x28-ft. room devoted to the pumps and tanks for the hydraulic elevator plant, while in front is the equipment of refrigerating machinery, occupying a 10x35-ft. space. Along the outside edges of the basement there are seven fan equipments and heating chambers for the indirect heating systems, with air filters, temperature regulating apparatus and steam piping connections.

Boiler Plant.—The steam generating equipment consists of three Scotch marine type internally fired shell boilers, each of 250-h.-p. capacity, located in a boiler-room depressed 10 ft. below the basement level in order to secure ample headroom. This type of boiler was adopted at Senator Clark's personal suggestion. The boilers were built by P. Delany & Co., Newburgh, N. Y.; each is 10 ft. 6 in. in diameter by 13 ft. 3 in. long and has 168 3-in. tubes, giving a total heating surface of 2,500 sq. ft. The shell plates are 7/8 in. thick, with quadruple riveted double butt strap longitudinal seams and 1¼-in rivets, hydraulicly driven. All tube and rivet holes were drilled in position by special machinery. The boilers are designed for operation at 160 lb. working pressure. Each has two corrugated furnaces, 45 in. in diameter by 10 ft. 10 in. long, with patent furnace fronts, and is fitted with special grates having 55 sq. ft. of area per boiler. The back smoke connection is in each case separate and attached to the boiler with bolts, provision being made for a 24-in. clear space inside the fire-brick lining, which is carried throughout the connection. The furnaces are operated with natural draft, a breeching 48 in. square leading to a 48-in. circular steel stack at the rear of the building which is carried up to a height of 100 ft. above the boiler-room floor. This stack is of 3/8-in. steel plate, resting at the base on a foot of special construction, and rises within an enclosure 52 in. square to the third floor level, above which it is encased in a round brick stack. The stack is surmounted by a cap of ornamental cast bronze with which is incorporated the exhaust head from the power plant.



Basement Plan of the new Residence of Hon. Wm. A. Clark in New York.

The boilers are fed by two 7½x4½x10-in. Blake pumps, with receiver and pump governor, which are located in the pumproom adjoining and discharge through a Worthington hot-water meter to a 3-in. feed line of polished brass over the boilers, with a 2-in. branch to each. The feed-pump delivery connections are duplicated and interconnected so that the feed pumps may be interchanged with the house pump and the swimming tank pump, and the delivery connections through both the feed water heater and feed water filters have bypasses, thus forming a most flexible arrangement of connections. The feed-water system begins at a 7x10x6-ft. reservoir tank, with 4-in. suction lines to the pumps. This tank is connected with the mains in Fifth Ave. and 77th St. by two 8-in. services. The city supply is supplemented by the returns from the heating system, which are delivered with the drips from the steam mains to the reservoir. The feed-water is heated in a Wainwright vertical closed heater of 250 h.-p. capacity, which is supplied with exhaust steam by a 4-in. branch from the exhaust main and is drained by a Royal trap. The feed-water supply is purified before entering the reservoir by two sets of Loomis-Manning water filters in duplicate, one in each of the residence supply connections from the street, and again before entering the boilers by another set of filters of similar make and capacity, through which the feed may pass either before or after heating in the feed-water heater. Each set of filters consists of two units of 2,500 gal. capacity per hour and has washing connections for flushing out to the sewer.

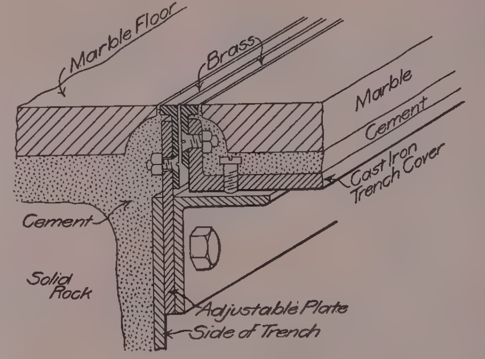
The boilers have 2½-in. blow-off connections with Y-blow-off valves and heavy bronze stop cocks in tandem, which deliver to a 3-in. main discharging into a blow-off tank in the boiler-room. The boiler branches have special T-connections for observation and cleaning, the openings in which are fitted with heavy brass plugs for ease of removal. The blow-off tank is a 24-in. by 14-ft. cylindrical steel tank arranged horizontally along the westerly side of the room, from which the water is raised to the sewer level automatically by a 4½x2¾x4-in. Blake pump controlled by a Kieley pump governor. The tank is kept half filled for cooling the blow-off and drips discharged into it, and further cooling is effected by a coil of 60-ft. of 2½-in. brass pipe within the tank, through which the cold feed passes from the pumps on its way to the feed water heater.

Piping.—The high-pressure steam piping has an 8-in. header for the supply of the turbo-generators and a 6-in. header supplying the pumps and auxiliary equipment. The 8-in. main has 6-in. branches to each boiler, each having two stop valves with a T-fitting and a small vent valve between for absolute relief of that branch from pressure if desired, and is carried across into the turbine room where 3-in. connections are made to each unit through Cochrane separators. The 6-in. auxiliary main has 4-in. branches with similar connections from each boiler, and is first carried to the pumproom where connections are made to the feed, house and Underwriters' pumps, and also to a pressure-reducing valve for a live-steam supplemental connection to the heating main, and thence into both the elevator machinery room and the refrigerating machinery room for the operation of the pumps. The heating main connection is made through a 6-in. Curtis pressure-reducing valve, with 4-in. steam supply and an 8-in. delivery to the heating main. Connections are also made from this main to the domestic water heater and the swimming tank heater in the pump room, to the coil in the hot room of the Turkish bath, and also through a reducing valve to the kitchen cooking apparatus.

The exhaust steam system originates in the turbine-room where the 8-in. exhaust outlets from the turbines connect into a 10-in. main which is carried in a trench beneath the floor surface into the pump room. It is there joined by the exhaust connections from the various pumping machinery and thence passes through a tank grease separator for the removal of lubricating oil. This separator is a 45-in. by 6-ft. cylindrical steel receiver with condensing grate and oil dam for the water separation process, and is fitted with overflow and blow-out connections, with a steam trap in the former connection for drainage. From the outlet of the separator, connection is made to the feed-water heater and to domestic water heaters, each through 4-in. branches, and beyond this the heating main starts. The atmospheric relief connection from the exhaust main is made through an 8-in. branch in the turbine-room, connecting to a riser carried up in the smoke-stack shaft. The exhaust head is of copper and is fitted into the head of the smoke stack so that the smoke opening encircles its base while the steam outlet is on top. The riser has a noiseless back-pressure valve at its base and has drip connections from both the base and the exhaust head to the blow-off tank.

Turbine Units.—The electrical equipment includes three 75-kw. Curtis steam turbine generating units of the new horizontal type which has recently been perfected by the General Electric Co. These turbines are designed for non-condensing operation, their exhaust to be used in the steam-heating system of the residence, and embody special features for operation with a minimum of noise. The floor space required by each complete unit is 4 x 12¾ ft. and the over all height is 6 ft. 7 in.; the foundation base required is only 3¾ x 8¼ ft. They will run at 2,400 r.p.m., driving directly 250-volt, four-pole, direct-current generators, of special design for operation at this speed. The electrical distribution system of the residence is laid out on the three-wire system, and a 5-kw. balancer set will be used for equalizing the load on the two sides of the system.

Trenches.—An interesting feature of the mechanical installation is the entire concealment of all piping systems. All steam, water and other piping connections from the pumproom to apparatus and risers in different parts of the basement have been run in trenches beneath the corridor floors, of which an extensive system has been laid with covers that are easily removable for the inspection of the piping. The system consists of a main trench 48 in. wide by 36 in. deep, which leads from the boiler-room into the pumproom, thence at right angles through a passageway to a longitudinal corridor extending beneath the center of the residence and under the latter throughout its entire length. From this main trench there are numerous branches of differing sizes to the various sections of the basement, and in addition a second main trench 24 in. wide by 24 in. deep leads from the pumproom beneath the refrigerating machinery room to the west end of that section of the basement. The general arrangement of this trench system is indicated in dotted lines in the accompanying basement plan.



Details of Trench Construction.

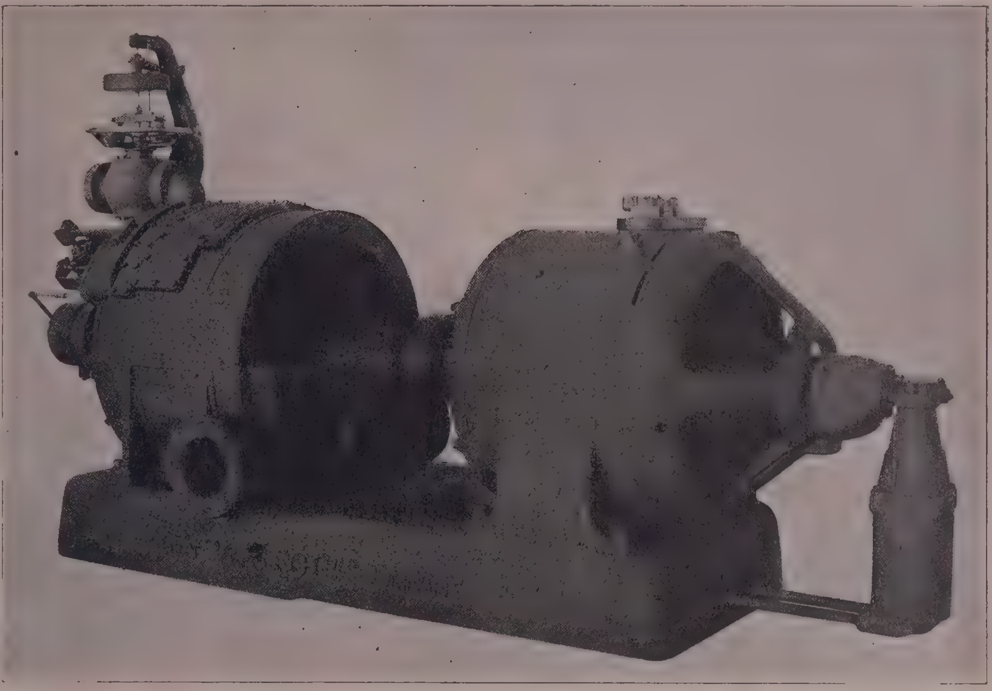
The trenches are of steel plate construction throughout, in most cases of ⅜-in. plate, built up with strong angle iron reinforcement and top flanges. The trench sections are flanged externally and riveted together in place so as to be water-tight, and have been carefully graded for the drainage of condensation to the boiler-room. The trench covers have been interestingly laid out so as to present a flush finish at the basement floor level while still rendering all sections easily accessible. The top of the trench sides are fitted with adjusting plates and angle-iron brackets which project inward to carry heavy ribbed cast-iron cover plates. To the adjustable plates and upper edges of the cast-iron trench covers, bronze brackets are attached with projecting lips or flanges, the recesses thus formed above the trench covers and also at the sides of the trenches, form spaces into which the tile floor is laid, so as to finish flush with the brass parting brackets, and thus only the edges of the brass joints at the sides and ends are visible in the finished floor, no other parts of the trench construction being in sight, except tapped openings for lifting hooks. The latter consist of bronze sockets riveted to either end of each cover section, but so designed as to not project obtrusively through the floor finish, and into these the lifting eyes or handles are screwed when necessary to open the trench.

Waterproofing Pits.—The location of the boiler-room 10 ft. below the basement floor introduced difficulties, as the excavation extended several feet below the level of ground water. To exclude infiltration into the boiler-room, the excavation was lined with a special steel plate pan or tank which was built into place in the sections with riveted joints calked watertight. The tank takes in the entire boiler-room space, 42½ ft. long by 26 ft. 2 in. wide and is 10 ft. deep. It was built in 38 sections with heavy angle and I-beam bracing and at the lower sides has rounded corners. The flooring of the tank was laid upon 12-in. I-beams spaced 2 ft. 6 in. apart, which were carefully leveled in the excavation and the space between them filled with concrete. The bottom plates were fastened to these beams by tap bolts screwed into the upper flanges, and all floor seams are butt joints made with straps 4 in. wide. The side walls were stiffened to withstand the pressure of filling by 4-in. I-beams riveted on the inner sides at 5 ft. spacings. They are carried up to the top edges of the tank, and their heads are fastened to the anchors in the rock. The I-beams also form means of holding the tank linings in place. The tanks are lined with 4-in. hard red brick, with a further facing of 4 in. of glazed brick, making an 8-in. wall, bonded and held in place by the upright I-beams. The tank has proved tight.

Similar construction was resorted to in the installation of the tank for the swimming pool in the westerly end of the basement. This tank is 28 ft. 7 in. long, 18 ft. wide and 7 ft 9 in. deep, and is built of 7/16-in. steel plate. Its flooring is carried on 10-in. I-beams spaced 2½ ft. apart, which are bedded in concrete at the base of the excavation. To these the floor plates are fastened by ¾-in. tap bolts into the upper flanges, and vertical stiffening used for the side wall consists similarly of 4-in. I-beams spaced 5 ft. apart. The sides of this tank have anchorages of heavy forged prongs, 10½ in. below the upper rim, which project outward and are imbedded in the surrounding masonry, in order to withstand the pressure of the earth fill behind. This tank is lined with white Carrara glass, and there are wainscotings of similar material surrounding this room and all other rooms of the baths.

Heating Systems.—The heating of the greater portion of the residence is accomplished upon the indirect system, supplemented in corridors, in auxiliary rooms and at exposed points by direct radiation. Only on the two top floors, which are devoted to servants' quarters and to the laundry, is the indirect system departed from, direct radiation being used there exclusively. A novel feature of the installation is the use of seven separate indirect heating sections, each serving a distinct portion of the building and operated by an independent blower system, an unusual arrangement adopted in preference to a central heating plant with the attendant long runs of supply ducts and connections. For each system there are small auxiliary rooms or heating chambers, into which cone fans blow air from exterior basement window intakes through filters. These auxiliary rooms contain the heating stacks, one for each group of supply risers, which risers in some cases project into the room and enclose the heating stacks provided for them individually, so that all air entering them passes through the heaters at their bases. Heating is accomplished by exhaust steam with vacuum returns, and all radiation, as also the indirect system supply outlets, are under automatic temperature control.

There is a fan and heating chamber equipment at each of the four corners of the building, and two on opposite sides near the middle, and a natural draft equipment without fan is in the rear extension. All have their fresh air intakes through short exterior openings into courts at the basement level, and have fresh air distribution or heating chambers of the size merely sufficient to contain the air filters and the necessary heating stacks. Little space is thus required, yet the equipment is rendered thoroughly accessible. The group at the northwest corner of the building (group A) is the largest, having a heating chamber nearly 150 ft. long, and thirteen heating stacks, which supply twenty warm-air risers. By this arrangement, however, long duct lines and branches to supply the risers are entirely avoided as the heating stacks are located very close to the inlet openings of their risers and are furthermore easy of access. In all but two of the remaining indirect groups, practically the same arrangement is carried out except on a smaller scale. In group C, however, a number of branch ducts from 20 to 25 ft. were required, while in group H the entire distribution is handled by a single duct on the turbine room ceiling.



The New 75-kw. Curtis Turbine in Power Plant.

Boiler Room of Clark Residence Power Plant.

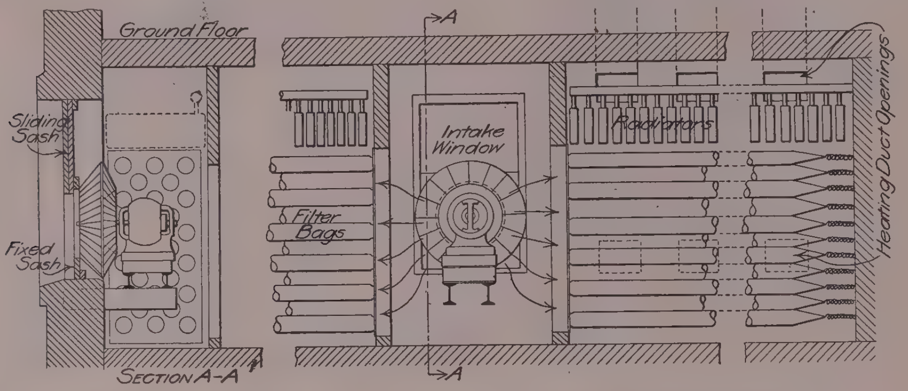
Blowers.—The blowing equipments used for these indirect systems consist of individual motor-driven cone centrifugal fans of copper plate construction with cast-brass centers which have been installed in the sizes and capacities in cubic feet per minute shown in the accompanying table.

Group.	Fan.	Capacity.	Speed.	Motor.
A	60 in.	10,100 cu. ft.	325 r.p.m.	10 h.-p.
B	48	5,250	400	6
C	48	4,400	400	6
D	42	3,900	475	4
E	42	3,900	475	4
G	42	3,900	475	4

They are in all cases mounted in enclosures in front of the window intakes and deliver into the heating chamber through air filters on either side; the enclosures have bypass connections to permit of operation of the systems with natural draft if desired. The motors are mounted on I-beam brackets projecting from the masonry beneath the window, and the fans are keyed directly to their armature shafts without other bearing support. Four-pole Sprague motors are used throughout, operating at 250 volts with 50 per cent. speed control, and were installed with special provisions for noiseless operation.

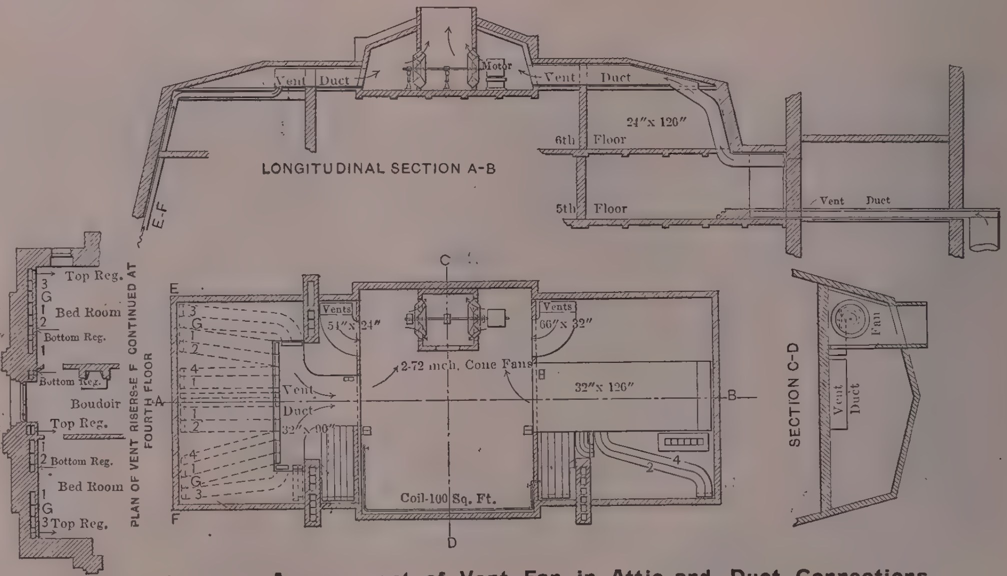
Intakes and Filters.—Systems A, B and C have their intakes through outside basement windows while the others draw through windows opening into interior courts at the rear of the building. These openings are all fitted with copper wire screens of ½-in. mesh and No. 12 wire to prevent the entrance of birds and foreign matter, and have three sets of sash for different combinations of inlet, bypassing and closing. The sash are all fitted with steel plate diaphragms in place of glass, and the lower sash with the circular opening for the fan intake is stationary, while the other two are movable, so that if both are lowered the fan is bypassed, while if only one is lowered the entire system is shut down. The fan with its motor is located in close proximity to the lower sash opening, delivery being made through the enclosure in which it is located, which serves as a plenum chamber out of which the air passes to the filters.

The air filters are horizontal cheese-cloth bags, suspended in the heating chambers, through which the air is passed in entering from the intake chamber. As indicated in an accompanying sketch, the intake chamber is separated from the adjacent heating chambers by partitions with sheet metal doors, made to serve as the filter bag supply diaphragms. They are fitted with as many 12-in. collars as their area permit, which project through into the heating chamber, and on them are mounted by strap fastenings the cheese-cloth bags, which are 12 in. in diameter and are in all cases made as long as the chambers permit. In order to support the bags horizontally they are tapered at the far ends and fitted with hooks by which they are fastened to the wall with long volute springs. A result of this arrangement is that the door may be easily opened for access to the heating chamber at any time, the bags merely dropping back loosely as the doors are arranged to open inward; when again closed, the bags stretch out straight under the tension caused by the supporting springs. In practice it is found that the cheese-cloth tubes tend to collapse ordinarily toward the ends away from the supply connections, opening up as is necessary to pass the air delivered, and when clean, the air is passed with ease, only a fraction of the tubes being inflated by the pressure of the air in passage. They thus become dirty at the supply ends first after which they open up farther from the supply connections as additional filtering area is required, it being a fortunate feature of this arrangement that, when the tubes are fully expanded throughout their whole length, it is an indication that they are dirty and should be replaced by clean ones. In the design of the air filters it was the purpose to provide as large areas of filtering medium as possible for slow filtering velocities and consequent maximum efficiency in the filtering process; in some cases filter bags 16 ft. in length were found possible, by which filtering capacities far in excess of the requirements were secured while in no case has the design been such as to produce a velocity of delivery through the filters as high as 60 ft. per minute.



Blower and Filter Arrangement in Typical Heating Chamber.

Stacks and Ducts.—The indirect radiators are mounted in the upper portions of the heating chambers, in continuous lines above the filter tubes in some cases, and in distributed groups in others in which each group is incased by a casing connecting with the riser duct supplied. With the former arrangement the entire space above the radiators serves for hot air delivery, into which the supply risers to the upper floors open directly. The radiators are a drum type of a special construction with corrugated sides, which are mounted side by side across the heating chamber and have steam supply connections from above and return connections below at opposite ends, so that any section may easily be removed. The sections are each 41½ in. long and 8 in. high, presenting a heating surface of 10 sq. ft., and are distributed on 3⅛-in. centers. In system A, where distributed groups of radiators have individual connections to their risers, the radiation is sheathed in each case in a jacket of No. 18 galvanized iron, the lower side of which is left open for the air intake while the upper side has a full-size connection to the riser duct.



Engineering Record

Arrangement of Vent Fan in Attic and Duct Connections.

The indirect supply connections to the upper floors have separate ducts for each of the rooms supplied, which are located in chases in the wall construction. The risers are in all cases of double thickness and the chases before receiving them were lined with No. 20 galvanized iron fitted and soldered to insure continuity. Each riser is carried down to its heating chamber, with an opening above the radiation and a bypass opening to the cold air space below, which openings are dampered for mixture of the supply and consequent temperature control. These openings have horizontal leaf dampers interconnected with links so that when the hot air connection above the radiation is open, that into the cold air space below is closed, and vice versa. The dampers are operated with graduated movement by pneumatic damper motors under control of thermostats in the rooms supplied, and are constantly being adjusted to deliver the supply temperature required by the varying conditions in the rooms. The upper ends of the hot air flues are in all cases carried to the ceilings of the rooms supplied, so that the outlet connection may be made at any point necessary to meet requirements of the interior decoration scheme. It has been the practice to locate all supply connections at points 7 ft. above the floor line or higher, for downward ventilation, and they are proportioned for rates of flow of from 350 to 400 ft. per minute, decreasing to 250 to 300 ft. at register outlets.

The indirect radiators are supplied with steam from a heating main carried for the greater part in ceiling trenches with a number of return pipes. This main originates at the live steam supplemental connection in the exhaust steam line in the pump room, and has four branches, one of 6-in. piping supplying groups A, B and C, one of 5-in. piping supplying group F and the greater part of the radiation on the upper floors, the third a 4-in. line supplying groups C and E, and the fourth a 3-in. line supplying group F and direct radiation upon floors above. The supply riser which is carried from the 5-in. branch up to the attic is a 4-in. line with distributing connections at the top supplying a number of drop risers for the direct radiation on the two upper floors of the building. All rising lines are anchored at about one-quarter of their length from each extreme, the anchor being a forged strap of special design built into the walls for a rigid support. Expansion is provided for by slip expansion joints, and the lines are kept in alignment by cast-iron guides. These lines are in all cases run in chases lined with No. 26 galvanized iron, which is rigidly supported and carefully soldered air and watertight; in installing, the chases were first lined and then after the pipe lines were all in place and thoroughly tested, the chase lining was completed over the front and permanently sealed. The lining is made with joints lapping downward on the inside and continuous from the fifth floor to below the basement ceiling so that damage from leakage is absolutely prevented.

The return lines parallel both the basement heating mains and the heating lines upon the upper floors for the return of condensation to the vacuum pumps. Indirect heating groups A and B are served by a 3½-in. return line, group C and the Turkish bath fixtures by a 3-in. line, and similarly groups D and E, groups F and G and the radiation upon the two top floors by separate 3-in. lines, and group H in the corner and radiation upon floors above in the faience gallery by a 2½-in. line. These lines extend longitudinally through the basement and all join a 4-in. main in the pumproom leading to a pump governor from which the returns are handled by feed pumps to the boilers. The return system is operated without automatic valves, all radiation having thermostatic control upon both supply and return connections.

Temperature Control.—The thermostatic system of temperature control has been applied to all radiation throughout the building, all direct radiators having two thermostatic valves, one for the supply and the other for the return connection. The indirect radiators have similar thermostatic valves between the regular valves and the header, and controlled by thermostats placed in the cold air chamber beneath the coils, the object of which provision is to keep steam shut off from the coils until the outside temperature drops to 60° F. For this indirect supply control special thermostats are used with wide ranges of regulation, so that the temperature can be adjusted as desired; they are located in the rooms served and operate the mixing dampers in the corresponding supply risers so that when the temperature in the room rises the hot air damper closes and the cool air damper opens, and oppositely, when the temperature drops, the hot air damper opens and the cool air supply closes, the change taking place within a range of one degree. The direct radiation upon the upper floors and all skylight coils are similarly controlled. The Nash temperature regulation equipment has been installed throughout, and compressed air is supplied to the system by a steam-driven air compressor with storage reservoir in the pumproom.

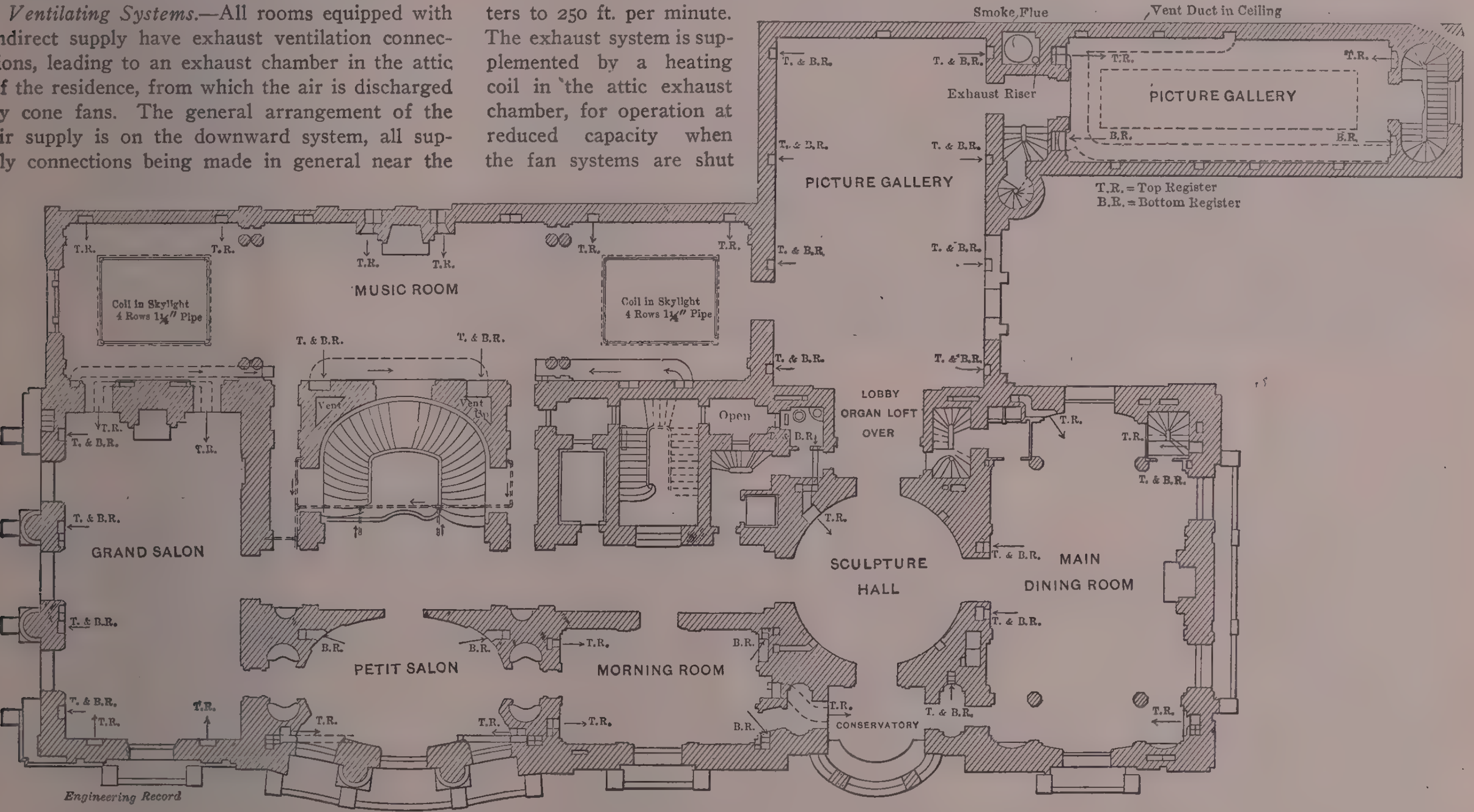
A special heating equipment is used in the conservatory on the first floor, consisting of a coil of 2-in. brass piping presenting a heating surface of 60 sq. ft., which is enclosed within a 10-in. brass pipe filled with water for hot water heating. The 10-in. reservoir has a water supply connection and an expansion tank of copper. The steam supply to the internal pipe has thermostatic control on both supply and return connections, the thermostat being connected to the water reservoir so as to close the steam supply when the water has reached a temperature of 180° F.

All skylight coils in the music-room, galleries and elsewhere are of bronze piping with thermostatic control upon inlet and outlet and are in all cases provided with copper gutters suspended beneath the coils and of sufficient size to intercept any possible leakage that might in any way occur. These gutters are of 16-oz. tinned copper and have brass drip pipes for the removal of possible leakage.

All steam tables, plate warmers and other cooking equipment in the kitchen and pantry are operated from the heating system mains with the necessary supply and return connections.

Ventilating Systems.—All rooms equipped with indirect supply have exhaust ventilation connections, leading to an exhaust chamber in the attic of the residence, from which the air is discharged by cone fans. The general arrangement of the air supply is on the downward system, all supply connections being made in general near the ceiling and in no case lower than 7 ft. above the floor line, while the exhaust openings are in practically all cases at the floor line. In a number of special cases, however, particularly in bathrooms, there are exhaust openings at both floor and ceiling. The vent risers are, like those for the supply, in nearly all cases concealed in chases in the side walls with all horizontal runs and branches carried in furred ceilings. In general arrangement, the various exhaust riser ducts are carried up individually to the attic exhaust chamber except in the east portion of the building, where the majority of them are combined and carried up in large flues owing to discontinuance of the building above the fifth floor in this portion; the risers are there combined into two 12x65-in. ducts, which are carried across under the fifth story floor to risers, 40 in. square, leading up to the sixth-story ceiling and thence by a 24x126-in. connection to the exhaust chamber in the attic. The vent risers from the west portion of the building, 25 in number, join into a 90x32-in. vent duct which leads across to the central exhaust chamber, 26 x 34 ft. in plan by 8 ft. in height. The 24x126-in. connection above the sixth-story ceiling, serving the east portion of the building, has connected to it, before entering the exhaust chamber, 13 additional individual risers from the central portion of the building, the duct increasing to 32 x 126 in. in section.

The main exhaust ventilation system is operated by two 72-in. cone fans in the central exhaust chamber in the attic, one on either side of a vertical outlet shaft 8 ft. square, which is carried through the roof to a large copper exhaust cap. The fans are mounted in tandem on a single shaft and are operated at 300 r.p.m. by a single 20-h.-p. Sprague motor, each fan having at this speed a capacity of 16,000 cu. ft. per minute, making a total exhaust capacity of 32,000 cu. ft. per minute. These fans were built, with the supply fans, by the American Blower Co. This capacity is so proportioned to the riser duct capacities that the rates of flow secured in them average 400 ft. per minute, which is reduced at inlet registers to 250 ft. per minute. The exhaust system is supplemented by a heating coil in the attic exhaust chamber, for operation at reduced capacity when the fan systems are shut down; this coil is so located as to induce a draft in the exhaust ducts and consequent ventilation at reduced capacity. It is a ceiling coil radiator of 100 sq. ft., and is connected with the heating and return mains on the sixth floor.



Heating and Ventilating Connections on the Main Floor.

The design of the ventilating systems provides for four to six changes of air per hour in all rooms served, according to the conditions of occupancy, and the relations of supply to exhaust will produce a plenum in all rooms except the bathrooms, auxiliary rooms and the kitchen and serving rooms, which are designed for inward draft to prevent communication of odors to the remainder of the building. In the plenum rooms the supply connections average 10 per cent greater in capacity than those for exhaust, while in bathrooms the exhaust connections are generally of capacity double that of the supply. In a number of dressing and other auxiliary rooms the supply and exhaust connections are equal, while in the corridors there are supply connections only, no exhaust being provided except in the skylight louvres.

In addition to the main exhaust system, an auxiliary system has been provided for the ventilation of the natatorium, Turkish baths and dressing-room in the basement, which is operated by a 54-in. cone fan in the basement with independent discharge carried above the roof line. A special exhaust chamber is provided for this portion of the basement above the furred ceilings, from which connections are carried to the exhaust fan in a room at the rear. This fan has a capacity of 9,000 cu. ft. per minute, is direct-driven by an 8-h.-p. Sprague motor at 400 r.p.m. and discharges through a duct 36 in. square to an exhaust flue provided in the heavy masonry surrounding the semi-circular grand staircase; the flue is triangular in shape and is discontinued at the fourth floor, being carried thence by a rectangular galvanized iron flue, 2 x 3½ ft. in section, to an outlet hood above the attic roof level. It is thus entirely independent of the main ventilation system so that, with the design for a strong plenum inward at the baths, through no circumstances of back drafts may steam and odors of the bath be communicated to the remainder of the building.

A feature of the attic vent chamber construction is the lining of the outlet opening to the air with 16-oz. copper, seamed with standing joints soldered watertight, and the waterproofing of the floor portion of the chamber to a depth of one foot upon all sides; this floor is connected with a 2-in. waste pipe, for the removal of any possible leakage from the roof or from the elevator tanks located therein.

The residence was designed by Messrs. Lord, Hewlett & Hull, with Mr. K. M. Murchison, Jr., associated. The heating and ventilating equipment and the power plant were designed by Mr. William J. Baldwin, consulting engineer, New York. The contractors for the heating and ventilating installation were the Rossman & Brackman Co., New York. The elevator plant is of the plunger hydraulic type and was installed by the Standard Plunger Elevator Co., New York. The refrigerating equipment is an absorption system of 6 tons capacity and was installed by Steele & Condict, Jersey City, N. J.

A Large Shale Brick Factory in Eastern Illinois.

The plant of the Western Brick Co., at Danville, Ill., has a capacity of producing 200,000 brick a day, about 40 per cent. of which are paving blocks and the remainder shale building brick of every class. The entire output of the plant is manufactured from shale obtained in the immediate vicinity of the plant, over 90 per cent. of the brick produced being vitrified. The plant is on a tract of 350 acres of shale and coal-bearing land on both banks of the Vermilion River. The geological formations underlying this tract are almost perfectly regular, although the strata of the different materials encountered vary somewhat in thickness. The surface soil is a stratum of loamy sand and gravel, 3 to 16 ft. in depth. Immediately underlying this sand and gravel is a stratum of shale, 18 to 55 ft. thick, which extends practically without a break under the 350-acre tract and under a large territory in the vicinity of this tract. This shale, which is quite dense and uniform in character, makes excellent brick and is used principally in manufacturing building brick. A 6-ft. vein of bituminous coal of good quality is directly under this stratum of building brick shale. Below this 6-ft. vein of coal are, successively, 5 ft. of fire clay, 20 ft. of shale that is unsatisfactory for brick, a second vein of bituminous coal 8 ft. thick, a second 5-ft. stratum of fire clay, then a 15-ft. stratum of sandstone, which is just above a 15-ft. stratum of shale that has been found to be specially adapted to the manufacture of paving brick. Under this last 15-ft. layer of shale is another deposit of shale, 200 ft. thick, which is not utilized at present.

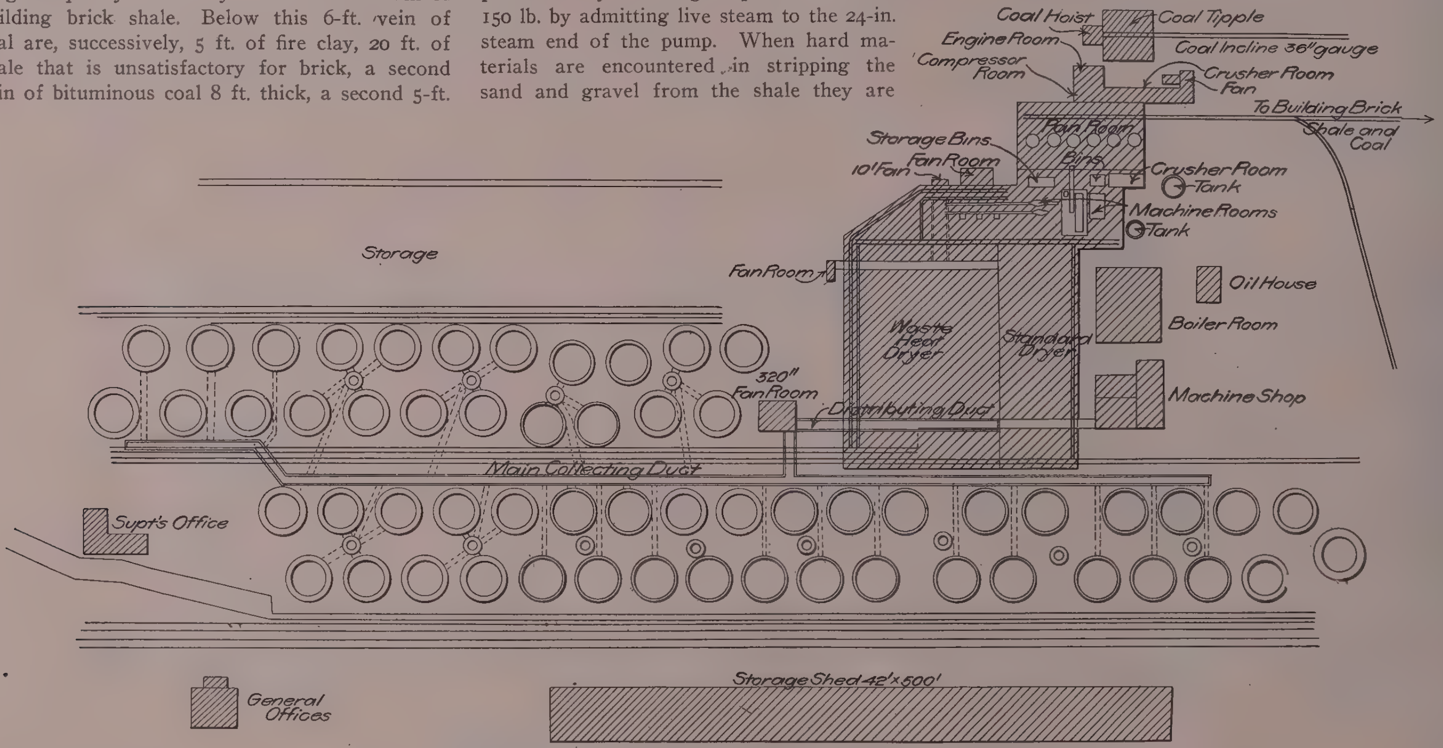
The brick plant is about 1,500 ft. from the river. The greatest part of the building brick shale that has been used has been taken out in the space between the plant and the river. The 3 to 16-ft. layer of sand and gravel on the surface is stripped from the 18 to 55-ft. stratum of shale with hydraulic monitors. The shale is then excavated with a steam shovel, after which the 6-ft. vein of coal is taken out and used in the operation of the plant. The shale from the 15-ft. stratum which is used in making paving brick is mined from a vertical shaft at a point where this stratum is about 160 ft. from the surface.

The hydraulic equipment used in stripping the upper layer of shale and the methods followed in carrying on this work are such that the material is moved at an exceedingly low figure. A compound duplex Smith-Vaile steam pump, with a 16-in. water end and 16 and 24-in. steam ends, is installed on the bank of the river. This pump is supplied with steam by a 72-in. by 16-ft. tubular boiler in a house on the hill just above the pumping station, and is so arranged that live steam may be turned into the 24-in. steam end when extra water pressure is required. The pump normally operates at a pressure of 115 lb. per square inch at the discharge. A 10-in. pipe line extends from the pumping station to the point where stripping is in progress, the maximum length of this line that has been laid thus far being 4,000 ft. The 10-in. line is extended up to somewhere near the face of the bank that is being cut away, where it is tapped with two 4-in. pipe connections that are carried up to within 20 to 50 ft. of this face. Each of these 4-in. connections ends in a 4-in. hose carrying a 2½-in. nozzle. These nozzles are fitted with an adjustable needle point through which the size of the stream issuing from them may readily be changed from ½ to 2½ in. in diameter. The normal pressure at the nozzle varies from 75 to 100 lb., depending on the location of the work with reference to the pumping station. This pressure may be brought up to as much as 150 lb. by admitting live steam to the 24-in. steam end of the pump. When hard materials are encountered in stripping the sand and gravel from the shale they are readily removed by thus increasing the pressure and reducing the size of the stream at the same time, the smaller streams under the heavy pressures readily cutting through the shale.

A system of operation has been developed in stripping the sand and gravel and in removing the shale underlying them which is at once simple and economical. A 70-ton Bucyrus steam shovel, with a 2-yd. dipper, is used in excavating the shale. This shovel works against a face 35 to 40 ft. wide and equal in height to the thickness of the stratum of shale, which is generally about 30 ft. The shovel loads the shale into 3-yd. bottom and side dump cars made by the Petteler Portable Railroad Mfg. Co. The cars are hauled in trains to the foot of an incline leading from the pit to the crushing machinery of the plant. They are hauled up this incline, which is about 400 ft. long, and is largely on a 25 per cent. grade, by a Lidgerwood hoisting engine at the top of the incline.

Formerly the coal directly under the shale was not removed until after a considerable area of it had been uncovered. The shale is at present stripped clean from the coal and the latter taken out in strips the same width as the strip of shale removed by the shovel, immediately after the shale is removed. The sand and gravel that have to be stripped with the hydraulic monitors from the shale adjoining the cut just made by the shovel before a second cut can be started are run in sluices into the hole made by removing the last cut of shale and coal. The pit is well drained with sewers leading to the river so that the water from the hydraulic operations is readily carried away, leaving the sand and gravel in the pit. This method of working permits the strippings to be spoiled on waste ground and at the same time keeps the bottom of the pit at a practically uniform level. Formerly a number of small gulches were filled with the surface strippings from the shale in order that coal could be taken out later. One of the largest of these fills was made in a gulch so near the limits of the company's land that provisions had to be made to prevent the sand and gravel spreading over the adjacent property. A fill, 125 ft. wide, with a practically vertical face 20 ft. high, was made by the hydraulic process without permitting any of the sand or gravel to escape past the defined limits of the fill. A barrier of brush and straw carried up on the face of the fill as the latter was raised, held the sand and gravel back and allowed the water to escape. The resulting fill has never settled since it was completed and even during the time it was being made a team and wagon could be driven over it without leaving a track on the surface.

The steam shovel will soon be started against a face cut, 3,500 ft. long, which has an average depth of 20 ft., and will be taken out the full width of the range of the steam shovel dipper boom. A part of this cut has already been stripped hydraulically. The gravel and sand will be removed from the remainder of the cut as required, the hydraulic process making it possible to strip during the summer season as much of the shale as the shovel takes out during the entire year. A narrow-gauge railroad is being built from the plant along one side of the shale pit, then through a heavy cut and across the river to coal mines which are just being opened up on the company's property on that



General Plan of Western Brick Company's Plant.

side of the river. The river will be crossed on a bridge having a 100-ft. and two 40-ft. spans, with a fill of considerable size in the approach on the farther side of the river. The cut and a portion of the 3,500-ft. shale face are adjacent to the approach on the opposite bank. This cut is being made and the shale will be stripped with the hydraulic monitors. The fill in the approach on the farther side of the river will be made hydraulically with material from these two cuts, the material being carried across the bridge in sluices extending from the site of the hydraulic cutting operations.

The average cost of moving the sand and gravel hydraulically has not exceeded 2 cents per cubic yard, at the most, during the four years the process had been employed at this plant. On the average about 2,000 cu. yd. of material are moved every 10 hr. by the hydraulic process. The nozzles are anchored on swivels so they can be handled readily by two men. A fireman and an engineer are the only other men required in the operation of the hydraulic plant. The cost of stripping the shale is somewhat more expensive than the cost of simply moving the sand and gravel, owing to the fact that the surface of the shale has to be cleaned perfectly, requiring the stream to be held on it for some time after the sand and gravel have been practically all removed. The material that has been encountered has been moved as far as 1,600 ft. in sluices on grades as flat as 3 ft. in 100 ft. Practically every kind of material except plastic clay has been readily moved and transported by the hydraulic process.

Moving Sand and Gravel with Hydraulic Monitors.

About 200 tons of bituminous coal are required in burning the kilns and in the boiler furnace of the brick plant, 50 per cent. of which is obtained from the 6-ft. vein of coal under the stratum of building brick shale. This coal has in the past been broken out with powder after the steam shovel has removed the shale. The coal was then loaded in cars by hand and hauled up an incline to a chute near the plant by an electrically driven Lambert hoist. A locomotive crane hoist is to be installed in the pit just back of the steam shovel and will load the coal into cars on the same track on which the clay cars are operated. The shale and coal may thus be taken out practically at the same time. The crane can also be used in cleaning up any shale or strippings that may fall in on the coal after the shale cut has been made by the shovel.

The shale from the 15-ft. stratum which lies at a depth of 160 ft. is mined by the regular room and pillar system of mining, the 15 ft. of sandstone directly over it forming an excellent roof. This shale is too hard to be drilled with the ordinary rotary drill and too soft for a punching drill, but blast holes are readily made in it with Howell's rotary air-driven mining drills, four of which are employed. Dynamite is used exclusively in blasting, as the shale is too dense to be loosened economically with black powder. A Norwalk compressor, with a capacity of 400 cu. ft. of air a minute, is placed in a house at the mouth of the shaft and supplies power to operate the drills. The shale is brought to the surface by a hoist in the same house and is discharged into a hopper leading to a Champion rock crusher.

General View of Brick Plant from Shale Pit.

The incline from the building brick shale pit ends in a head house at one side of the machinery room of the plant. Under and on each side of the end of this incline are 6 chutes into which the cars on the incline dump automatically. The mine shaft is at one side of the head house and the rock crusher is in the latter. The shale from the mine after passing through the crusher is raised in a bucket elevator and discharged into three of the six chutes under the end of the incline. These chutes each feed into one of six dry pan crushers set in a row along the opposite side of the end of the incline from the mine. The building brick shale and the shale from the mine are mixed together to make the paving brick. This mixing is done in the chutes supplying three of the dry pans. The dry pans all deliver to bucket elevators leading to overhead screens. The screened shale is discharged on a belt conveyor which carries it to a storage hopper over two pug mills.

Nearly all of the brick produced by the plant are made according to the stiff-clay process. A soft-mud machine is used in making a small percentage of the building brick manufactured. The brick machinery is all in one long building extending back along one side of the end of the incline. The soft-mud machine is in a room at one end of this building. Two Chambers brick machines are used in the stiff-clay process, one for making building brick and the other for paving brick. These machines are next to the room in which the soft-mud machine is located. They are supplied with the prepared shale from the two pug mills under the hoppers into which the belt conveyor from the screens delivers. These Chambers machines each deliver a continuous column of prepared shale on a belt conveyor. About 15 ft. from each machine is an automatic side-cutting machine which cuts the column of shale into the proper sizes. The paving brick are repressed after being cut, in machines which place a pressure of 15 to 20 tons on each brick and imprint the trade name on the brick at the same time.

Four of these repressing machines are placed along the conveyor belt leading from the Chambers machine producing the paving brick. The belt conveyor from the other Chambers machine extends beyond these repressing machines, the two conveyors being parallel. A narrow-gauge track is laid on each side of the brick machines and the two conveyors. The green brick are transported on cars from the machines to the drying rooms. These rooms are at one side of the machinery room. Tracks extend through them into the machinery room, the brick being moved on iron-frame racks on four-wheeled trucks. The brick from the stiff-clay machines are dried with the waste heat from the burning kilns. The brick from the soft-mud machines are dried by steam in a separate room.

There are 57 circular hand-fired brick kilns operated in connection with the plant. These kilns are in four rows with a central aisle between the pairs of rows as shown in the accompanying general plan of the plant. These rows are at right angles to the longitudinal center line of the drying rooms, and the central aisle passes along the rear of those rooms. Tracks are laid from the drying rooms along the three aisles between the rows of kilns. The brick are hauled along these tracks from the drying rooms to the kilns on the same racks on which they were loaded at the brick machines.

The brick are burned from 7½ to 10 days in the kilns and then allowed to cool 36 to 48 hr. before the kiln is opened. During the cooling process dampers are closed in the flues and the waste heat from the kilns is drawn through ducts and exhausted into the drying rooms. A 7x8-ft. brick-lined duct, 800 ft. long, is laid beneath the central aisle the length of the rows of kilns. Connections are made to this duct by branch ducts leading to the flues of the kilns or by sheet-iron ducts placed in a door of the kiln. A 320-in. steel-plate exhauster, made by the New York Blower Co., furnishes suction in the ducts and discharges the waste heat into the drying rooms. This exhauster is direct connected to a 16x20-in. slide-valve Frost steam engine and is guaranteed to exhaust from the kilns and supply to the drying rooms 200,000 cu. ft. of air a minute when running at 115 r.p.m., the pressure against which it discharges being ¼ to ½ oz. On the average, 300,000 lb. of water are removed from the brick in the drying rooms every 24 hr. Circulation in these rooms is maintained by two exhausters, one an 84-in. and the other a 120-in. disc exhauster. Owing to saturated condition of the air removed from these rooms these exhausters have been found too small to permit the 320-in. exhauster to produce its maximum efficiency and an additional exhauster is to be added to supplement them.

Two railroad switch tracks are laid along each side of the four rows of kilns. These tracks are depressed so that the floor of the cars on them is flush with the pavement around the kilns. The tracks are so arranged that brick may be loaded to 60 different cars at the same time. The brick are placed in storage sheds on the opposite side of these tracks when the production of the plant exceeds the demand.

The machinery of the plant is practically all operated from a central power station. The boiler equipment consists of six 72-in. x 20-ft. Atlas tubular boilers, which are supplied with water from a Stillwell-Bierce feed-water heater. A 24x48-in. Bates Corliss engine drives all of the machinery in the plant through line shafts, except such machinery as is operated continuously throughout the 24 hr. of the day. A 45-kw. Commercial generator, belt driven by a 12x18-in. Frost automatic engine, furnishes power for lighting and for several motors driving small machines, including a pump at the river. This pump delivers to an elevated tank near the power house. A system of 4-in. water mains for fire protection extends over the entire plant and is supplied with pressure by an Underwriters' fire pump.

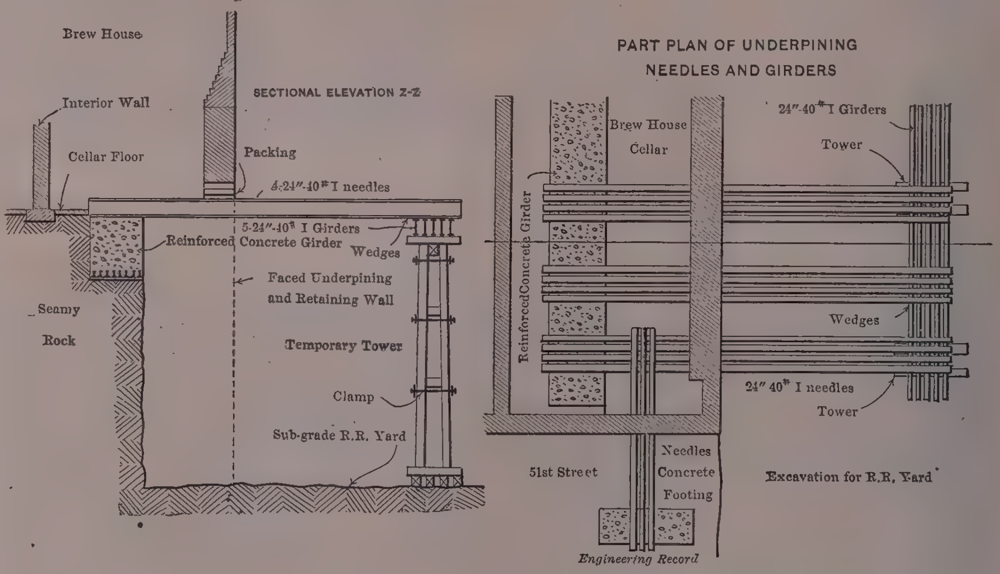
The shale building brick produced by this plant are used quite extensively in the section of the country in which the plant is located. Brick are now being supplied to the United States Government for the construction of the buildings at the new Fort Benjamin Harrison, near Indianapolis, in which work 8,000,000 of these brick will be used. The brick are required to have a modulus of rupture of 2,000 lb. per square inch when loaded at the center of a 6-in. span and to absorb not over 2 per cent. by weight of water. Over 4,000,000 of these brick have been delivered and accepted under these requirements. A comparison of the prices of these brick and of the coal mined in the same district shows how cheaply the process of manufacture has to be carried on. The coal is sold at $1.10 at the mine, while these brick are sold for about $1.75 a ton. The shale has to be handled 14 times before it reaches the cars as brick and a ton of coal is required to burn each ton of brick.

The plant is operated under the direction of Mr. F. W. Butterworth, general manager of the Western Brick Co.

Gas Engines are being somewhat extensively installed in Sicily, owing to the scarcity of good water power and the high price of coal on the island. They are said to be superseding steam power, as under the conditions the cost of operation is lower than that of steam engines. A 400-h.-p. Dowson gas engine has been installed in a recently reconstructed factory on the island, and the company contemplates installing two 250-h.-p. gas engines.

Underpinning a Tall Brewery Wall on Rock Foundations.

The west wall of the Schaeffer Brewery on Park Ave., between 50th and 51st Sts., New York, is adjacent to the extension of the terminal yards of the New York Central & Hudson River Railroad Co. At this point the yards are being extended the full width of Park Ave. up to the front wall of the brewery and are being depressed to a depth of about 40 ft. below the street level. This brings the excavation to the face of the wall foundations, and although the latter were built on rock they were jeopardized by the excavation below them because the rock on which they were seated is of very poor and unstable character. It is of the micaceous gneiss that abounds in this vicinity and the stratification is extremely irregular. At this point the rock contains numerous seams inclined but a few degrees from the vertical and sloping downward toward the excavation. Some of these seams are several inches or a foot in width and are filled with earth and decomposed rock which affords a very unstable foundation, especially since secondary seams, inclined about as much from the opposite side of the vertical, intersect the main seams and divide the rock into small portions liable to be crushed or separated from the main body if the lateral support afforded by the original formation is disturbed or the equilibrium beneath the surface is destroyed.



Reinforced Girder, I-Beams and Tower Supporting Needlebeams.

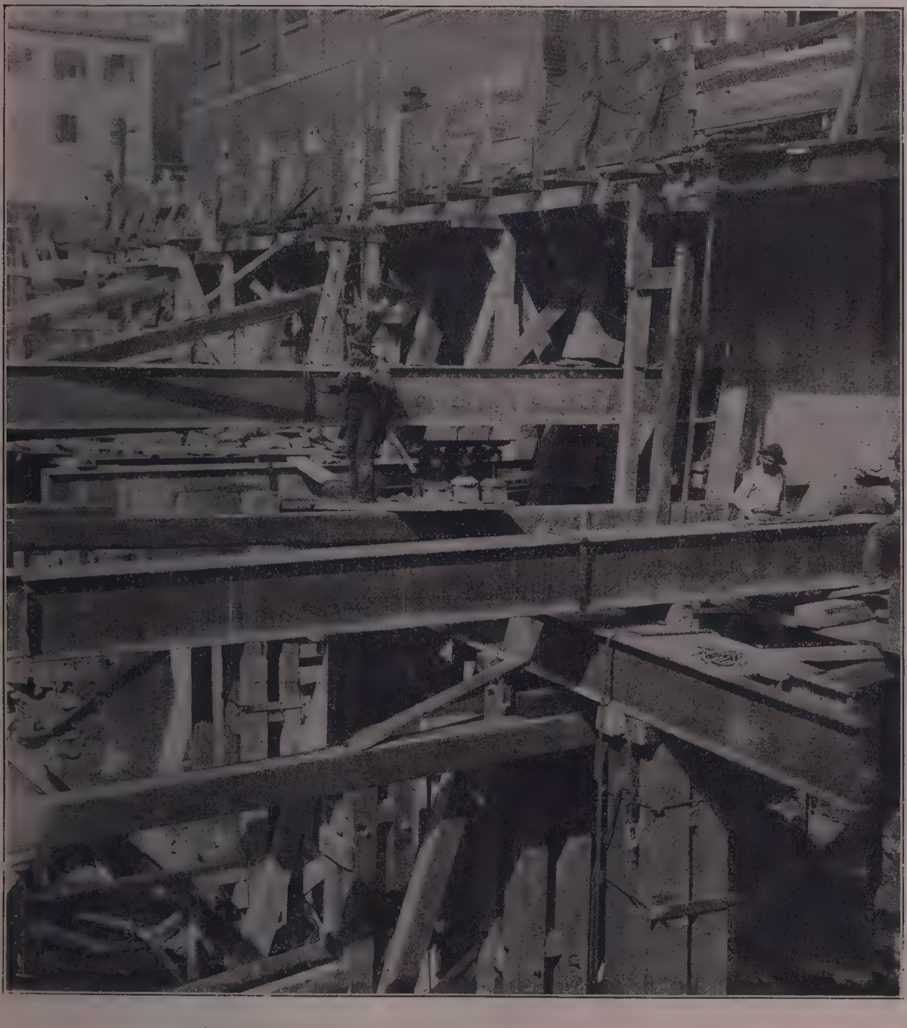
It was therefore deemed necessary to underpin the wall with a new foundation, carried below the bottom of the excavation and serving as a thick retaining wall to protect the face of the rock up to the level of the cellar bottom. The building has five stories and a basement and consists of two portions, a brew house with a 35-ft. front at the north end and a malt house with a 165-ft. front adjacent to it and occupying the remainder of the lot. It was estimated that these walls carry a load of about 15 tons per linear foot, and on this basis the underpinning has been successfully accomplished.

The building is of old-fashioned construction, with the ends of the floor-beams resting on a 12-in. brick wall carried by a 3½-ft. stone wall reaching from about street level to rock at a depth of about 15 ft. As this wall was made with good stone and cement and was found in good condition, it was at first intended to trust to its strength and the arching effect of the masonry to carry the loads across short openings and to underpin the wall without needle-beams or other direct temporary supports. To this end the wall was braced by inclined timbers bearing against vertical distribution pieces on the face of the wall and spaced about 12 ft. apart. The feet of these timbers were securely wedged against the face of the preliminary excavation made in front of the wall to a depth of about 15 ft. When the face of the rock under the foundations was exposed and its character known the risk of this method was considered too great and preparations were made for supporting the wall on needle-beams.

It was determined to remove the old rock for a distance of 10 ft. back of the face of the building and 30 ft. below the original foundations of the wall, replacing it with a mass of concrete of the same dimensions serving as a new footing under the base of the old footing, thus retaining nearly all of the old footing and virtually carrying it down to subgrade of the new cut. Manifestly the inner ends of the needle-beams required support more than 10 ft. beyond the face of the wall and the condition of the rock was so bad that it was feared that its excavation up to the 10 ft. line might leave such an unstable mass that it would slip out from under the needle-beams and cause serious trouble.

The building contains a heavy interior wall parallel with the front wall and about 15 ft. away from it which limited the projection of the needle-beams inside the building. It was finally determined to dig a trench in the cellar bottom close to the partition wall and make there a concrete footing to carry the needle-beams and distribute their load over the surface of the unsound rock. When this was decided on it was evident that the construction might be very much strengthened by the insertion of steel bars in the concrete so as to form a continuous heavy girder parallel to the wall of the building that would possess bridging qualities as well as distributing ability and would still carry the needle-beams safely if portions of it were undermined by the removal of the adjacent rock, as feared. A trench was excavated in the rock to a depth of 7 ft. and a width of 6 ft. Three inches of concrete were spread over the bottom and on its surface were arranged longitudinal lines of old rails 6 in. apart forming reinforcement bars for the girder. Around and above these bars 1:3:5 concrete was rammed up to the cellar floor, making a massive girder continuous across the entire width of the brew house.

After its completion holes were cut through the base of the footing and in them were seated sets of three or four 24-in., 80-lb. I-beams, most of them 46 ft. in length. The groups were spaced somewhat irregularly, averaging 4 ft. apart in the clear, and the inner ends of the beams were seated directly on the concrete girder in the cellar of the brewery. The outer ends rested on longitudinal girders made of five continuous lines of 24-in., 80-lb. I-beams, also 46 ft. long, which, like the needle-beams, were selected from the contractor's stock in such lengths as were conveniently available there. Each group of I-beams, both for the needles and for the longitudinal girder, was clamped at intervals by narrow horizontal iron bars reaching across the flanges on opposite sides and connected by bolts through their ends, thus forming yokes which secured the beams in the required position. The bearings of the needle-beams on the longitudinal girders were several feet from the outer ends of the former and were made of pairs of thin steel wedges parallel to the longitudinal girder.



General View from New York Central Yard.

The longitudinal I-beams were seated on the caps of wooden towers about 30 ft. high and from 10 to 12 ft. apart on centers. Each tower was composed of four full-length 12x12-in. timbers battered about 1:48 in both directions. They were separated about 8 in. both transversely and longitudinally at the top by solid fillers to which they were securely bolted. At the foot and at one or two intermediate points they were separated by thicker pieces or short struts also well bolted so as to make a rigid construction. Yokes formed of pairs of light iron bars and connecting bolts were placed around the tower at several intermediate points and, being tightly screwed, thoroughly clamped its posts together. The feet of the posts were beveled slightly to rest on the horizontal surfaces of a timber crib-work a few courses in height which was carefully leveled and distributed the load over a somewhat enlarged area of the rock bottom of the trench.

The yard was excavated to sub-grade to within a foot of the face of the wall and the character of the rock which was determined by this excavation was such as to decide the contractors to adopt the underpinning method here described and the towers were accordingly erected about 9 ft. clear of the face of the wall.

After the needle-beams were in place the spaces in the wall above their top flanges were packed with blocking and in some cases with bricks and mortar to afford a solid bearing against the under side of the old masonry footing. Vertical timbers called "pump logs," with 70-ton jack screws in the lower ends were placed under the overhanging ends of the needle-beams just outside the longitudinal girder and these were simultaneously operated by two or three men at each screw until the needle which had been set with their outer ends a little below the level of their inner ends were raised to an approximately horizontal position and took the full weight of the wall, as was indicated by a slight crack appearing in the masonry at the level of the needle-beams. About one-half of the front wall of the brew house was thus supported while the underlying rock and the bottom portion of the old footing were carefully removed by light blasting and by sledging and barring.

A vertical wooden face was built up from sub-grade almost to the foot of the old wall and in the plane of its outer face and being well braced on the outside served as a mould for the new concrete footing. Sand, cement and broken stone were delivered on flat cars opposite the front of the building beyond the cut in which the underpinning towers were seated and at about the level of the bottom of the old wall. A mixing platform was established on these cars and concrete was mixed by a Ransome machine operated by a General Electric motor, and was delivered through chutes into the space between the form and the face of the rock, filling it to within about 2 ft. of the tops of the needle-beams. After it was thoroughly set, pairs of wedging stones were placed on it about 2 ft. apart in the clear and carefully bedded in the cement mortar. Pairs of thin steel wedges were driven between these stones until they relieved the needle-beams of the weight of the wall, transferring it to the new footing. Afterwards the needle beams were removed and the spaces between the wedging blocks were filled with masonry built up to the lower surface of the wall in the usual manner. At the corner of the building the adjacent end of the 51st St. wall required support for a distance of about 15 ft. This was readily provided by cutting a hole through the footing near the center and inserting in it a group of needle beams like those previously described. The outer ends of these beams rested on the distributing timbers laid on concrete bed on the surface of the rock and the inner ends were carried on the top flanges of the needle-beams provided nearest the end of the building to carry the front wall.

The work was subject to considerable delay and interruption, but was carried through with entire success and insures the complete safety of the building. The wall of the malt house adjacent to the brew house was underpinned in substantially the same manner, except that the reinforced concrete girder in the cellar was replaced by longitudinal timber sills laid on leveling beds of concrete.

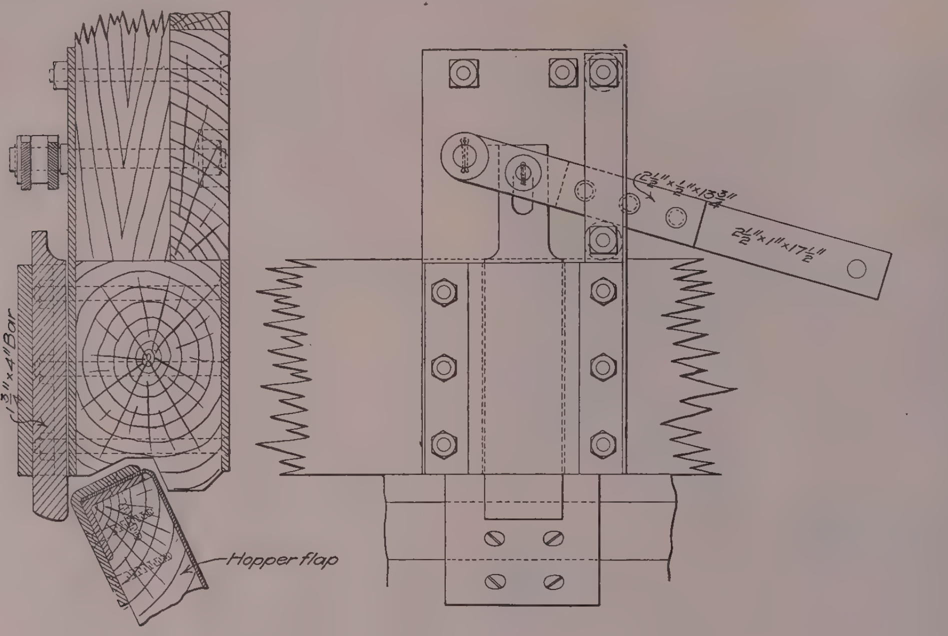
This work is part of that involved by the construction of the new terminal, the character of which has been described in several issues of The Engineering Record. It was conducted subject to the approval of the engineering department of the New York Central & Hudson River R. R., by the O'Rourke Engineering Construction Co., Mr. George Sergeant, Jr., engineer in charge of the Grand Central improvement.

A Special Caisson has been sunk at the foot of Fifteenth St., Jersey City, in the construction of a connection between the Hudson Company's tunnels from Morton St., New York, under the North River to Jersey City, with branches to the terminals of the Erie and of the Delaware, Lackawanna & Western Railroads. This caisson is near the working shaft for the main tunnels, and was sunk to facilitate the building of the divergent tunnels at their point of intersection. The single-track tubes of the connections are located to clear each other vertically and as the tunnel structure at this point could not be readily built by ordinary tunneling methods, special provision has been made for it by the use of a pneumatic caisson sunk 80 ft. or more through earth and water into the rock. The caisson, which is five-sided and is approximately 100 ft. long and half as wide, is constructed of reinforced concrete, affording a large estimated economy over the use of steel or timber. It consists of a massive concrete block containing a working chamber and an upper chamber separate from the latter. The working chamber eventually forms one section of the low-level tunnel; the upper chamber forms the corresponding section of the upper-level tunnel. The lower chamber was provided with an air-tight lining cemented in position to prevent the leakage of air pressure through the porous concrete. This caisson was built in forms on the surface of the ground, where the interior chambers were completed. Rapidity, economy and safety in the construction of the complicated masonry were thus secured which masonry would have been tedious and difficult to attempt to build underground.

The Depew Place Excavation.

The construction of the depressed yards for the new terminal of the New York Central & Hudson River Railroad Co., at 42d St., New York, involves the excavation of Depew Place for its full width of 50 ft. between 42d and 44th Sts., a distance of about 500 ft. There is here loose, dry, natural soil and fill to a depth of 15 to 25 ft., below which is the ordinary gneiss rock with uneven surface and irregular stratification. The quantities involved are approximately 25,000 cu. yd. of earth and 18,000 cu. yd. of rock, the contract for which was awarded to the Butler Bros. Hoff Co. Mr. Olaf Hoff, vice-president and engineer.

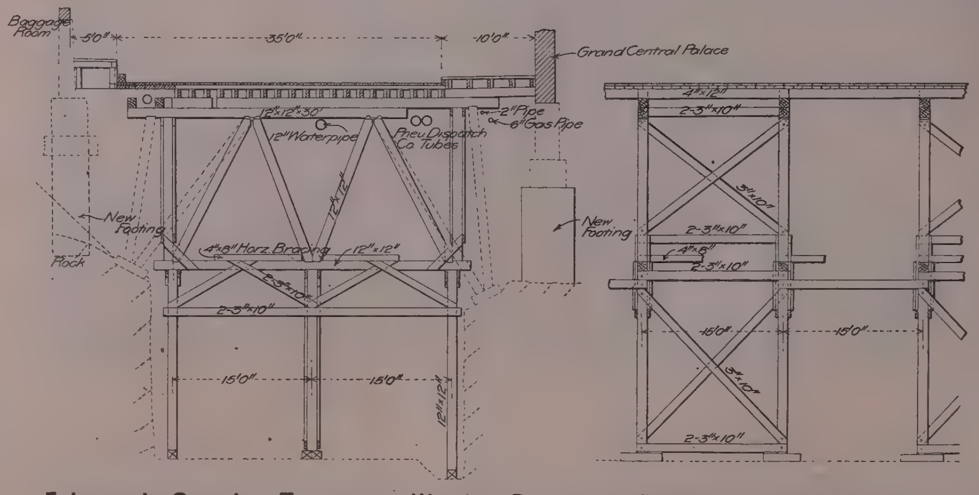
On one side of the street the full length of the area to be excavated is bounded by the baggage-room which has a continuous line of doors in the street wall through which baggage is being continuously delivered. On the opposite side of the street there is the 200-ft. front of the Grand Central Palace, which has been temporarily occupied by a branch of the United States Post Office, but is to be used as a temporary passenger station. These conditions unite to cause a very heavy traffic of trucks and wagons in the narrow street and to keep it almost continuously congested.



Latch for Bin.

One of the conditions of the contract provided for the execution of the work without interfering with street traffic, therefore the first step was to build a temporary wooden deck in the street to sustain traffic while the excavation is carried on underneath it. To accomplish this, small portions of the pavement were removed at night and the earth excavated to a general depth of about 20 in. Transverse trenches 12 in. wide, 24 in. deep and 15 ft. apart were made and in them were laid double 12x12-in. timbers. Additional longitudinal and transverse trenches about 4 ft. wide and 6 ft. deep below the general excavation were also made in convenient positions, and lines of 4x12-in. timbers. Additional longitudinal and transverse trenches about 4 ft. wide and 6 ft. deep below the general excavation were also made in convenient positions and lines of 4x12-in. joists, 18 in. apart on centers, were laid on the transverse timbers, parallel with the curb. These joists supported the deck consisting of one layer of 4-in. transverse planks covered with three-ply waterproofing flushed up at the edges, and a second course of 3-in. diagonal wearing plank. This platform extended close to the unloading platform on the depot side of the street and to the 10-ft. sidewalk on the opposite side, which was made with two courses of planks, and with joists farther apart. Between the two courses of plank, on both roadway and sidewalk, tarred felt paper was laid and coated with asphalt to shed water.

Under cover of this deck, the top of which was at the original street level, men entered the 6-ft. trenches and excavated the earth by hand, shoveling it into 1-yd. steel buckets on flat cars on industrial tracks of 20-in. gauge. As the transverse timbers were undermined by this process they were supported by cribbing, and as the height of the latter increased it was replaced by vertical and inclined shores which were finally carried down to rest on the surface of the rock and were very thoroughly braced by longitudinal and transverse diagonal pieces well bolted to them, thus substantially forming trestle bents and towers from 15 to 20 ft. high.



Falsework Carrying Temporary Wooden Deck over Depew Place Excavation.

As fast as the spoil was excavated it has been delivered on the narrow-gauge tracks to openings cut through opposite ends of the deck whence it is hoisted by boom derricks and dumped directly into wagons waiting there. Preparations have been made to replace this method by a system of elevators and towers designed to expedite the work and be more economical, but the construction of the plant has been delayed by the underpinning of the adjacent buildings so that a large part of the earth excavation has been handled as above described. The remainder of it, however, and the rock excavation will be handled by two 6x20-ft. vertical timber towers reaching to a height of 24 ft. above the street.

Each tower will contain two elevator platforms and turntables on which 1-yd. dump cars will be hoisted, revolved 90 deg. and dumped into two storage bins, each of 2 cu. yd. capacity. These bins will have hopper bottoms closed by side flaps hinged on the lower edge and counterweighted. The ends of these flaps will be provided with transverse steel hood pieces closing the sides of the aperture when the flaps are opened. When the flaps are opened they serve as aprons to chute the contents of the bin into the wagons below and the upper ends engage reaction timbers held in place by tension rods with spring adjustments at the lower end to reduce the impact on the tower. They can be operated either from above or by the teamsters, and as each one provides a definite amount of material they will fix the size of loads drawn.

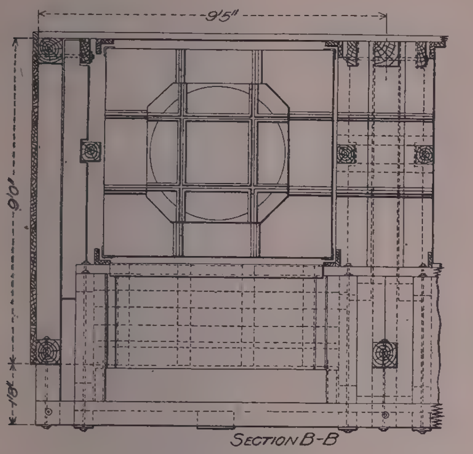
When the excavation was about 8 ft. below the street level the underpinning of buildings was started and carried on as described in The Engineering Record of June 30. After the completion of the earth excavation the transverse bents shown in elevation by full lines below the double caps will be replaced by inclined pieces shown there by dotted lines. The upper ends of the inner struts will engage cast iron angle blocks bolted and framed into the cap pieces and will form arches carrying the roadway over the trench and providing a clear space there for the unobstructed excavation. The rock will be removed as in canal excavation by bench work, drilling and blasting between longitudinal cuts made with two of the largest pattern Sullivan channeling machines. There are installed adjacent to the excavation three 150-h.-p. Fitzgibbons boilers and two Chicago Pneumatic Tool Co.'s air compressors, each with a capacity of 1,200 cu. ft. of free air per minute, which is used to operate the channeling machines, the Sullivan drills, the Lidgerwood hoisting engines, the elevator engines, a pump and a Smith concrete mixing machine. This work was designed and is being conducted under the direction of the New York Central & Hudson River Railroad Co., Mr. W. J. Wilgus, vice-president. Operations were commenced in January last, since which time a force of about 400 men has been employed, and it is expected that the excavation will be completed by October next.

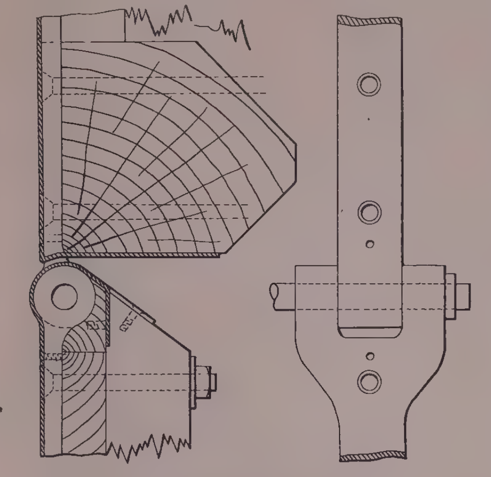
Photographic Cars for use of official photographers have been introduced upon the Southern Pacific Railroad. Each provides professional equipment and living rooms for four photographers.

The Development of Water Supplies and Water-Supply Engineering.

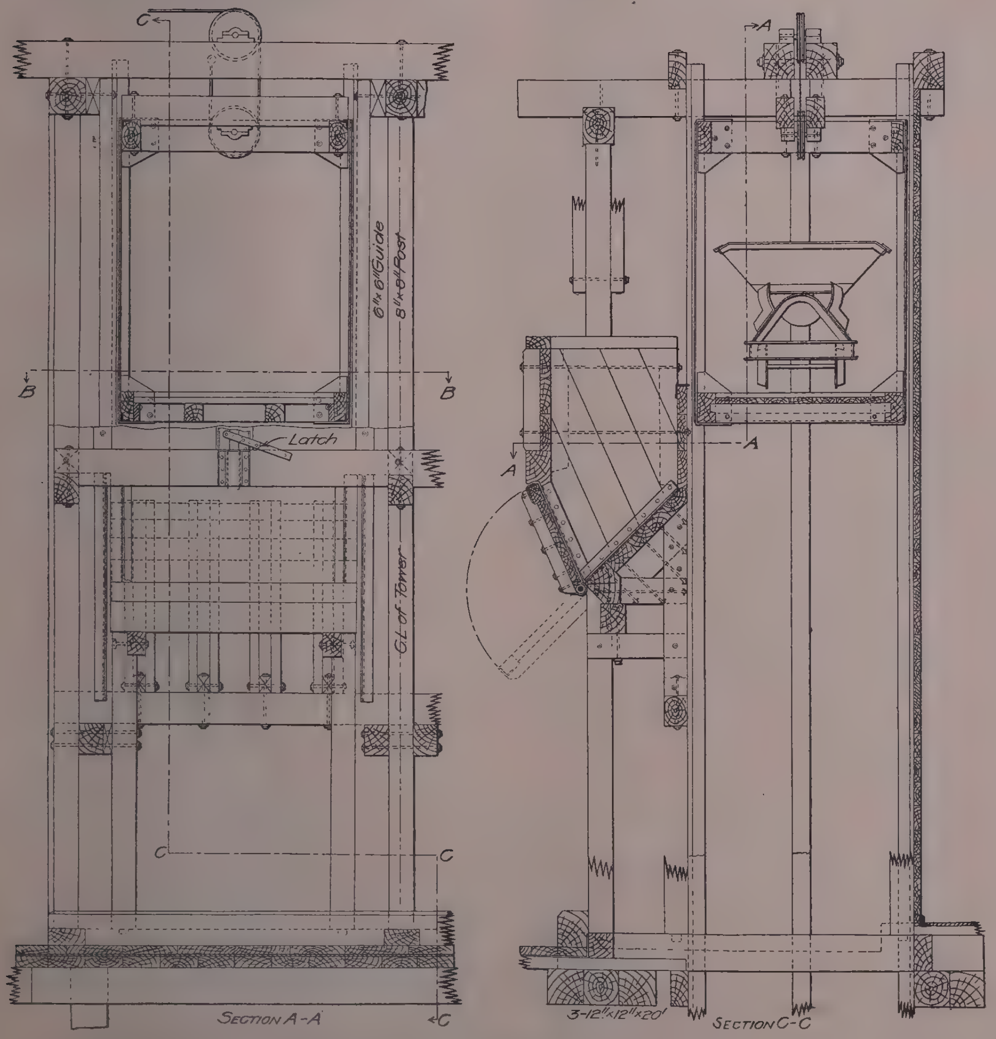
Annual Address of Mr. Frederic P. Stearns, President American Society of Civil Engineers.

In selecting a topic for the address which the constitution requires me to deliver on this occasion, I have found that there is ample precedent for speaking on the subject with which I am most familiar, namely, water supplies and water-supply engineering. I was the more ready to choose this subject because it gives me an opportunity to speak from my personal experience of the advantages of co-operation between engineers and those engaged along other lines of applied science.





Hinge for Spoil Bin.



Elevator Tower and Loading Bin for Spoil used in Excavating Depew Place.

It would be futile in a short address to attempt to trace the beginning of water-supply engineering. That it was not in its infancy in the Roman era is a matter of common knowledge, both from the carefully written descriptions of the water works of that era and from the remains now to be seen of the magnificent arches and other works near Rome and in former Roman provinces, which prove the great ability of the water works engineers of that period.

Works for both public water supply and irrigation existed at a much earlier period in Greece, as is attested by Homer in the following description of the gardens of Alcinous:

"Two plenteous fountains the whole prospect crowned:
This through the gardens leads its streams around,
Visits each plant, and waters all the ground;
While that in pipes beneath the palace flows,
And thence its current on the town bestows;
To various use their various streams they bring,
The people one, and one supplies the king."

Traces of water works have been found near cities which flourished in earlier periods; and, as human nature and the human brain have changed but little since the beginning of written history, it can hardly be doubted that from the time when people first gathered together in large cities there has been some public method of providing the necessary water for drinking and other domestic purposes. In the Middle Ages, and even in the period of the Renaissance, when the fine arts, literature and architecture flourished, the water works engineer, if he existed, built few if any works worthy of especial notice.

Of what may be called modern water works, London probably furnishes the earliest example. Before these were built there were, as is often the case, minor works for bringing water from springs near the city. One of them was completed in the year 1285, and others from time to time afterward, and there was obtained at a still later date a larger supply by pumping water with tidal power from the Thames at London Bridge.

The first extensive modern water supply, however, was that provided by the New River Water Works of London, built by Sir Hugh Middleton, in the four years from 1609 to 1613. The water was obtained from springs near the River Lea, distant about 20 miles in a direct line from London, but the open canal through which the water flowed to the city made many windings to avoid hills and valleys, so that it had a total length of 38 miles. The canal had an inclination of 3 in. per mile; its width averaged 18 ft., and its depth seldom exceeded 5 ft. The springs failed to furnish the required quantity of water, and were supplemented by a direct connection with the river. These were very great works for those days, when, to quote words written in 1835, "the science and practice of civil engineering were very little known." In 1633 London is said to have been well supplied with water from pipes in all streets, and in nearly every house the rent of which was from $75 to $100 a year.

The water companies had troubles then as well as now. The average remuneration for water was one farthing a barrel, but it is stated that "notwithstanding such palpable evidence of its cheapness, some persons have been loudly querulous concerning the high and unconscionable rate charged for water." Their complaints led to a parliamentary investigation. It is also noted among the troubles of the period that persons living near the open aqueduct used it for bathing. Under the laws then in force they could be prosecuted only for trespassing, for which the penalty was transportation. Considerations of humanity are said to have prevented the water companies from prosecuting the offenders.

After London was well supplied with water, 163 years elapsed before a public water supply worthy of notice was provided for any of the larger cities of America. The first one to be supplied was Boston, into which water was introduced by a water company in 1796. The water was taken by gravity from Jamaica Pond, situated a short distance outside the city limits. Philadelphia built its own works, which were supplied with water by pumping from the Schuylkill River, and were first operated in 1801. New York was first furnished with a water supply by the Manhattan Co. at about the same time. In all these cities the water was distributed through hollow logs, which are sometimes found well preserved at the present day.

The earlier water works in America seem not to have been well appreciated, as the revenue derived from the Philadelphia water works three years after the introduction of water was only $1,800 a year, and up to 1815 not enough had been realized from water rates in any one year to pay for the operation of the works.

The water supplies of New York and Boston continued to be wholly inadequate to the needs of the cities for many years, as money was not plenty, and the cities were loath to embark upon great enterprises with which they were unfamiliar. After long delay, however, they proceeded to build permanent works on a most liberal scale. New York, especially, displayed great courage in deciding to build an aqueduct 40 miles long, having a capacity of 80,000,000 gal. per day, from the Croton River to the city. This work involved the great difficulty of conveying the water over the Harlem River at a height of more than 100 ft. above its surface.

Having once begun the construction of modern water works, the rapid growth of American cities and the lavish use and waste of water have required a very rapid development of water-works systems in all parts of the country, and works of unprecedented magnitude are now being undertaken with less hesitation than the much smaller works of many years ago. The most notable of these recent undertakings is that of the city of New York for bringing water a distance of 100 miles from the Catskill Mountains, at an estimated cost of $162,000,000.

Let us now leave the development of water-works as a whole, and consider the development of their various parts and the influence which water-works engineering has had upon engineering along other lines.

The Romans were masters of the art of building masonry aqueduct bridges and aqueducts, and the advance upon their practice up to the present time is not very striking. We now build, however, aqueducts of much greater size, and have a knowledge of hydraulics and of leveling which enables us to produce much more efficient works. The Romans excavated long tunnels—one of them is said to have had a length of 3 miles—through which to convey water, but these must have been especially difficult to excavate before the days of explosives. Their greatest trouble was due to the absence of suitable pipes for conveying the water across low lands, and it was this difficulty which caused the construction of the aqueduct bridges to which reference has already been made. They had lead pipes, made by folding sheet lead and soldering the edges, and used tile and stone pipes in some instances, but none of them compared in efficiency with the modern iron pipe.

The date when iron pipes were first used for water works is uncertain; there are instances of their use as far back as the middle of the eighteenth century, but they did not come into general use until after the beginning of the nineteenth century. In 1746 the Chelsea Water Co., of London, laid a 12-in. flanged pipe to a reservoir at Hyde Park, which was taken up and relaid in 1791 "in consequence of its joints being perished." Another pipe laid a few years later in the Kensington Gardens was taken up in 1819 on account of incrustations on the interior surface of the pipe. A 5-in. iron pipe was laid to supply water to Edinburgh in 1787. The London companies changed from wooden pipes, which were in general use, to cast-iron pipes, between the years 1810 and 1820. Mr. Thomas Simpson, the engineer of the Chelsea Water Works, of London, designed the first bell and spigot pipes, about the year 1785, and at that time laid a few lengths of this pipe with lead joints as an experiment. Philadelphia, in 1804, laid about three-fourths of a mile of iron pipe as an experiment, and in 1817 began to use cast-iron pipes with bells, similar to those now in use. These pipes were imported from England.

It is of interest to note that as early as 1810 a 15-in. flexible cast-iron main with ball and socket joints at intervals was laid across the River Clyde to supply water to a portion of Glasgow. A trench was first dredged in the bed of the river, then the pipes, attached to wooden frames, were connected on land on one side of the river, and subsequently dragged across it until one end reached the opposite shore, the operation being aided by pontoons, much in the same manner that such work is done at the present time. The credit for the design of this siphon is due to the celebrated James Watt, the inventor of the steam engine, who, for some years, practiced civil engineering.

"A patent Steam Engine" was erected by the New River Water Co., of London, in 1787, and it is possible, though not probable, that this was the first application of steam for pumping a city water supply.

The steam engines first used for pumping water for Philadelphia, in 1801, were unique machines, as the walking-beams, flywheels, connecting-rods, and even the cold-water pumps, were made of wood. As indicating the difficulty of constructing such machines in this country at that time, it is said that the main steam cylinder of one of the engines was cast in two parts, and that nearly four months were occupied in boring it out fit for use. The boilers were wooden boxes bolted and braced on the outside. "The firebox inside the boiler was of wrought iron, with vertical flues of cast-iron."

There has been a very great advance in steam-engine practice since those early days, and the water works pumping engine, which has been developed by some of our most able mechanical engineers, has, much of the time, been in advance of other steam engines in efficient performance. It is worthy of note, however, that for a long time some of the Cornish engines, used in the mines of Cornwall, were the most efficient machines then in use, this result being obtained by a system of co-operation and nearly continuous tests, the results of which were published monthly. The triple-expansion water works pumping engine of the present day is a very perfect and smooth-running machine, which, with a high degree of economy, may lift a sufficient quantity of water to provide for the requirements of 300,000 people.

In the art of dam building the engineers of water supply and of irrigation have been rivals for many years. In India, and in recent years in the arid lands of our own country, the irrigation engineers have been designing and constructing great dams of masonry and of earth. Up to the present time, however, the water supply engineers have created the greater works.

The New Croton Dam, completed within the current year, with a height from the lowest point of its foundation to its top of 297 ft., is the greatest of masonry dams, although the mass of masonry is small in comparison with that of the Great Pyramid.

The San Leandro Dam of the Contra Costa Water Co., which supplies Oakland and other cities near San Francisco with water, is the highest of existing earth dams. It is an interesting feature that this dam, as well as three notable dams connected with the San Francisco Water Works—two of earth and one of concrete—were shaken by the earthquake of April 18, 1906, when under full water pressure, without any serious result.

Although the art of dam building has made such progress that great dams like those just mentioned have been designed and built of sufficient strength to withstand safely the tests of practical use, the theory of the design of both masonry and earth dams is only imperfectly understood. The rules given in the textbooks for designing masonry dams do not take account of some important forces affecting their stability, most of which are the result of temperature changes. Several of the more recent failures of masonry dams, most of them on southern rivers, could without doubt be traced to the neglect of the effect of forces which are not sufficiently considered in making designs. Experiments made during the last twenty years to determine the laws governing the filtration of water through sand and soils of various kinds have furnished much additional information for use in designing earth dams, and it has been found that, with proper designs, earth containing a large percentage of fine particles may be substituted successfully for a masonry or clay puddle core-wall.

There are some water-supply features which are not creditable to the American people. First, the great waste of water which prevails in most of our cities, and second, the taking of water directly from polluted rivers without either filtration or long storage.

There is, among those who govern our large cities, an unreasoning opposition to the introduction of water meters, which are conceded by nearly all who know about such matters to be the most efficient means for diminishing the waste of water. The recent action by the government of one of our larger cities emphasizes this point. This attitude seems to have some relation to the commonly expressed view that water should be as free as air, and that on sanitary grounds, it is not well to restrict its use, but no one has yet demonstrated the sanitary advantages of a leaky faucet or a defective ball-cock.

Experience shows that meters prevent waste, but do not prevent the use of as much water as is required for sanitation. Waste not only adds greatly to the difficulty and expense of obtaining a sufficient water supply, and requires the expenditure of money which might well be applied to improving the quality of the water by filtration or otherwise, but it adds greatly to the difficulty and expense of the sewerage system especially where pumping and purification of the sewage are necessary. There is undoubtedly a rapidly growing opinion among water works engineers and those connected with water works management that the general application of water meters is desirable, and the public and the governing bodies of our cities will in time become educated so that they will accept this view.

While I have said that the taking of water directly from polluted rivers is not creditable to the American people, I should add that under the leadership of the engineers and sanitarians of the present day this discreditable feature is fast disappearing. There is also to be said, as an excuse for the practice years ago when many such water systems were inaugurated, that the purity of water was then judged mainly from a chemical standpoint. Bacteriology was unknown, and the efficacy of filtration was not appreciated.

To show the point of view held thirty-three years ago, I quote from a paper written by one of the most prominent water works engineers of that time: "The object of filtration is to remove the visible impurities of water and render it colorless. * * * There is also, to a limited extent, a lessening of the chemical impurity." On the other hand, although the effect of filtration in rendering water wholesome was not so well known, there was ample precedent for filtering river waters, as it had been practiced in Great Britain since about the year 1811. In 1827 there were enough places where filter-beds were in use in England and Scotland to induce Mr. Thomas Simpson to make a trip of investigation, and he then visited filtration works in various places which were said to have proved completely efficient. In 1835, a writer, after referring to the entire success of the filter-beds built by Mr. Simpson in 1829, offers this prophecy: "Probably at no very distant period the desirable practice of filtering the whole of the water supplied from rivers to the inhabitants of great towns for domestic use may be universally adopted." While this prophecy may have been fulfilled in

England from the time when it was made, it is only approaching fulfillment in America.

The first well-equipped plant for filtering water through sand in America was built at Poughkeepsie, N. Y., from plans prepared by the late James P. Kirkwood, past-president, Am. Soc. C. E., and adopted by the city in 1869. This municipality had the honor of possessing the principal filtration plant of this kind in the United States for many years.

The work of the State Board of Health of Massachusetts, in regard to the purification of water and sewage, is well known, but I should leave out an important part of the development of water supplies and water supply engineering, were I to omit it; moreover, the organization of this work gives me one of several opportunities to speak from my own experience of the advantages of co-operation between engineers and those engaged along other lines of applied science.

This Board, by a law passed just twenty years ago, was given general supervision of the streams, water supply and sewage disposal in Massachusetts, and was required to advise cities and towns as to the appropriateness of sources of water supply and the best method of disposing of the sewage. Mr. Hiram F. Mills, the eminent hydraulic engineer, and chairman of the committee on water supply and sewerage of the Board, after learning how little definite information was then available on many phases of these subjects, with wonderful foresight initiated the now classical examinations and experiments which have resulted in so great an increase in the knowledge possessed by the water supply and sewerage engineers of the present day. In this work he was ably supported by the chairman of the Board, Dr. H. P. Walcott, an eminent sanitarian. The speaker was at the time the chief engineer of the Board. For making these examinations and experiments a staff of chemists, biologists and bacteriologists was engaged, comprising as leaders such men as the late Thomas M. Drown, professor of chemistry in the Massachusetts Institute of Technology, and afterward president of Lehigh University, and Prof. William T. Sedgwick, of the Massachusetts Institute of Technology; and in the ranks such men as Messrs. Allen Hazen and George W. Fuller, members Am. Soc. C. E.

While this is not an address on sewage purification, I cannot refrain from stating that the experimental work for the purification of sewage and water was planned and executed under the personal direction of Mr. Mills, who, although serving on an unpaid board, gave to this work the largest part of his time for several years.

The examinations of the water supplies of the State with which the speaker was more intimately associated, and the continued analyses of the waters, proved the great value of the co-operation of engineers, chemists, biologists and bacteriologists, as was recognized by all who participated in the work. These advantages may not be as fully appreciated at the present day, when there is no difficulty in finding individuals who are well acquainted with the engineering, chemistry, biology and sanitary history of water supplies, and who are in many cases experts along more than one of these lines, but men with such knowledge did not exist twenty years ago, and that they are available to-day in this country is to be credited to a large extent to the work of the Massachusetts Board of Health.

Continuing with the subject of the co-operation of engineers with those in other branches of applied science, I wish to express my indebtedness to a skilled geologist, who, from extended examinations at the surface of the ground, with the assistance of only a limited number of borings, predicted with a high degree of accuracy the character of the rock to be encountered in different parts of several aqueduct tunnels; who, in extensive boring operations, assisted by his advice as to the best method of obtaining trustworthy samples of the material penetrated, and who, by painstaking work and the resources of the geologist, interpreted the results of some important borings more accurately than they could have been interpreted by the engineers.

It is perhaps unnecessary to refer to the importance of consulting an architect when important buildings are to be erected, because it is now the general rule to do so, but there are more exceptions to the rule than there should be.

It is less common for engineers to consult a landscape architect, as many have faith in their ability to produce pleasing results with geometrical forms. The results of such co-operation in my own experience have been particularly satisfactory, as the carrying out of a landscape architect's plan, made before beginning work, has resulted in pleasing effects at little additional cost. (Mr. Stearns here referred at some length to the results of co-operation of this kind in connection with the construction of distributing reservoirs, and showed a number of views illustrating the effects of proper treatment of the landscape surrounding reservoirs.)

The relative advantages of municipal and private ownership of public utilities is a live question in municipal circles at the present time, and in the discussion of this subject water supplies furnish the most valuable object lessons. In the days of Greece and Rome, the aqueducts and other works were built by the kings and emperors, and operated under their direction. The question of municipal ownership arose in more modern times, when the municipalities became wealthy and to a large extent self-governing.

The Hampstead Heath Water Supply, for a portion of London, was built by the municipality and finished in 1590, but about one hundred years after, in 1692, it is recorded that the muncipally owned water supplies taken from sources within 5 miles of London were sold to the Hampstead Water Co. After this sale London was supplied by private companies until 1904, when all the immense works for supplying water to that city were again taken by the municipality.

In America the water works of Philadelphia were municipally owned from the beginning, but the earlier supplies for New York and Boston were introduced by private companies.

There has been for a long period of years a movement toward the municipal ownership of water supplies, and most of the larger water works in America and in Europe are so owned. The municipally owned water works, as a rule, have been successful in all respects.

In this address I have endeavored to give a brief account of the development of water supplies and water supply engineering, covering both water supply as a whole and in some of its more important features. I have found it necessary to call your attention to the great waste of water as one of the discreditable features of American water supplies, but I have indicated that the responsibility for this lies with the governing bodies of our cities and not with the water works engineers. As a result of the great waste of water, however, the engineer has had occasion to build works of unprecedented magnitude, and he has built dams, aqueducts and other water works structures so well that there have been few failures to record. He has installed pumping engines which are unexcelled in efficiency and capacity, and the works built, as a rule, have been financially successful under municipal as well as under private ownership.

The quality of the water supply of many American cities has been far below the proper standard, but improvements have been effected so rapidly within the past few years that it can be confidently claimed that under the leadership of the engineer and sanitarian a high standard in this respect will soon be reached.

Fuel Economy.

Abstract of a paper by J. Henry Hallberg, read before the recent convention of the National Electric Light Association.

Since the earliest days of steam production the great aim of engineers has been to devise improved means for the more complete utilization of the heat generated for the purpose of raising steam. It is to this early realization of the great importance of reducing the percentage of loss of heat that the rapid strides in this particular field are due, which have brought about the modern boiler installation, with its water-tube boilers, improved grates, mechanical stokers and economizers. It appears, however, that at first hardly any attention was paid to the personal element. and stoking was thought to be such a simple matter that very little loss or gain could be dependent upon it. In recent years it has, however, been realized more and more that the methods employed by the average fireman are anything but ideal, and that a great waste of fuel could be avoided if the results of stoking could be improved.

Observations, made over and over again in every-day practice, have proved conclusively that what is wanted is a more scientific mode of firing, and a more intelligent working of the furnaces—no matter what their construction may be —if the best results possible are to be obtained under the prevailing conditions. To achieve this, the first necessity is that these results should be known, not only to every engineer, but also to every fireman. It does not suffice to take occasional evaporative tests; these do not give a reliable record of the average performance of the furnace, nor do they show for one moment how the men usually work. Only continuous control and records can possibly furnish such information.

It is to-day universally acknowledged by engineers that the most reliable, most minute control of the results of combustion is obtained by means of continuous analysis of the flue gases and by determining the percentage of CO_2 (carbon-dioxide) they contain. To effect the complete combustion of a known quantity of fuel of given quality, a certain amount of atmospheric air is required, and just that amount—no more and no less—should be admitted into the furnace, because the percentage of CO_2 in the flue gases is directly dependent on the quantity of air admitted. It is this percentage of CO_2 which discloses whether or not the proper conditions prevail for such complete combustion.

Theoretically, the presence of 21 per cent. of CO_2 in the flue gases would indicate perfect combustion. In furnace practice it is, however, impossible to obtain good results when only the theoretical amount of air is supplied. A certain excess of air is required; this excess, however, should not be more than about 35 or 40 per cent. over the theoretical amount, and the percentage of CO_2, therefore, that would indicate the best practical results—that is to say, the highest attainable heat from the smallest amount of coal—is about 15 to 16 per cent.

It is a remarkable truth that even the best equipped but uncontrolled furnaces hardly ever show anything like this percentage; in fact, the great majority never reach more than about 7 or 8 per cent., corresponding to about 20 to 21 per cent. loss in fuel. This applies alike to hand-fired furnaces and stokers. In the great bulk of old type of boilers and furnaces the average result is not more than 5 per cent.

The enormous quantity of fuel thus continually being wasted is vividly revealed by a study of the following table:

Table I.

Relative losses of fuel, as compared with the theoretical lowest possible quantity, with various percentages of CO_2 in flue gases:

CO_2—per ct.	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Fuel loss "	90	60	45	36	30	26	23	20	18	16	15	14	13	12

It is in the power of every engineer to improve considerably the working results of the installation under his care, and to raise it to the highest standard of economy within the possibilities of the particular equipment, by keeping continuous records of the percentage of CO_2 obtained in the furnaces. A few days of experiment will determine the exact draft pressure necessary for the highest attainable combustion, and the dampers will be regulated accordingly. It will be easy to ascertain what method of firing will bring the best results, and what thickness of fire should be maintained.

Success in this depends only upon the practicability and reliability of the analyzing and recording apparatus, and in this point is perhaps to be found the reason why the apparently simple solution of the problem of fuel economy has not been generally employed in practice long ago. The apparatus was wanting. To be of any use, this must be designed to continuously and automatically analyze the flue gases and to continuously and automatically record the percentage of CO_2 directly on a diagram, thus forming a continuous and permanent chart, showing the results of combustion at any moment during 24 hr. It is further essential that the instrument should be worked without any great expense, and that a minimum amount of attention be required.

Several years ago Mr. Arndt, of Germany, invented and patented an automatic CO_2 recorder. A large number of these recorders have been in practical service abroad during the past four or five years, and in most cases the fuel saving has paid for the recorder in six months' time; in a few boiler plants the recorder paid for itself in a single month.

Some months ago this recorder was imported to this country and one was installed in the largest electric power plant in New York City. (The author doubtless refers to the 59th St. station of The Interborough Rapid Transit Co. The results obtained with the recording apparatus used in this station were fully described in The Engineering Record for Feb. 3, 1906, in a paper on Power Plant Economies, by Mr. Henry G. Stott.) The operation of the recorder was so satisfactory that three additional instruments have been ordered. Some large users of boilers in the country have also ordered recorders within the past few months, and several are now installed and are giving excellent service.

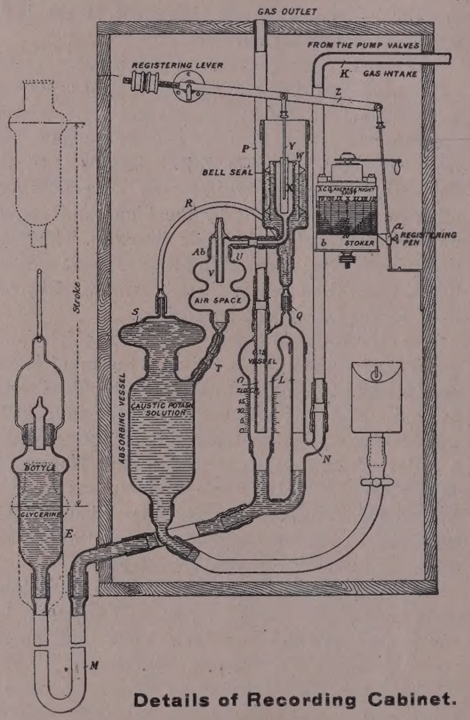
The working of the recorder is based on the well-known fact that a solution of caustic potash absorbs CO_2 gas (carbonic acid gas). The recorder consists essentially of an air motor, gas pumps and analyzing and recording apparatus.

The air motor consists of tank, bell and fittings, the interior of the bell being connected with the chimney by means of a tube. The draft in the chimney creates a vacuum under the bell, which is pressed into the tank by atmospheric pressure. Air is then admitted into the bell by the automatic action of a valve, and the bell rises again. This motion recurs about every five minutes, and it is utilized to raise and lower a bottle filled with glycerine, and to drive a pair of specially designed pumps, which pump flue gases through a tube from the chimney through the analyzing and recording apparatus. So long as there is a draft of one-half inch on water in the chimney the motor will work without any further aid or supervision.

The gas pumps consist of two cylinders, which dip into oil tanks and rise and fall alternately, drawing flue gases from the chimney, and forcing them through the recorder. As the pumps deliver about twenty times the volume of gas required for an analysis, the same gas is never analyzed over again.

The analyzing and recording apparatus consists in the main of a glass tube, which serves as a measure to bottle up 100 cubic centimetres of gases, of a bottle containing a solution of caustic potash, which absorbs the CO_2 gas, and of a pen which records the percentage of CO_2 gas ascertained in ink lines on a clock-driven chart.

The gases that are to be analyzed are forced into the recording cabinet by the gas pumps through the tube *K*, which is shown in the accompanying illustration. Bottle *E* is periodically raised and lowered through the action of the air motor and is in communication with the system of measuring tubes *L* by means of a flexible pipe, *M*. The bottle *E* is filled with a mixture of glycerine and water in the proportion of one part of the former to three of the latter; when the bottle rises, the liquid in the tubes *L* rises at the same time, and when it reaches the point *N* it closes the inlet for the gas from *K*. Contained in *L* is an inner gas escape tube, *O*, which is connected with the atmosphere by the pipe *P*. When the liquid reaches the bottom end of the tube *O*, exactly 100 cu. c.m. of flue gases are contained in the glass vessel *L*.



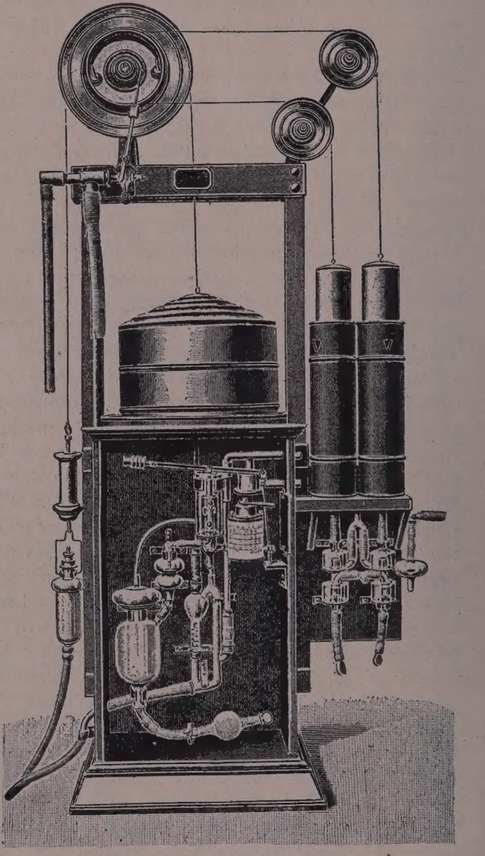
Details of Recording Cabinet.

As the bottle *E* rises farther the gases in the vessel *L* are gradually forced through the tube *R* into the vessel *S*, which contains a solution of caustic potash of 1.27 specific gravity. The whole of the 100 cu. c.m. of the gases have been forced over when the liquid in *L* reaches the mark *Q*, this being the point at which the air-motor reverses.

The moment the gases come in contact with the caustic potash in the vessel *S* the CO_2 is absorbed. The pressure of the remaining gases displaces the potash in *S* and forces it up the tube *T* into the air vessel *U*. When the potash reaches the bottom of the tube *V*, which connects *U* with the atmosphere, a certain quantity of air is bottled up in the space above. When the potash has risen to the bottom of the tube *V*, it has driven 60 cu. c.m. of air at atmospheric pressure out through the tube *V*; but on the potash rising further, it compresses the air in the upper part of the vessel *U* and raises the bell *W*, which floats on a glycerine seal. In the bell *W* is inserted an inner tube, *X*, which is closed at the lower end. To raise *W* to the point where the lower end of *X* touches the rod *Y*, twenty cu. c.m. of air are taken up, and the remaining 20 cu. c.m. (making up the 100 cu. c.m.) serve to raise the registering lever *Z*. To this lever there is attached the pan, *a*, which draws lines on the chart carried on the drum *b*.

The chart is calibrated in per cent. from 1 to 20, and the time is marked on it. For every per cent. of CO_2 absorbed, 1 cu. c.m. of air less is displaced, and the registering lever is made to rise 1 per cent. less on the chart. It will therefore be seen that when there is no CO_2 present the pen will rise to the top of the chart.

It is advisable to have one recorder for each furnace. Where it is, however, desired to test several furnaces by one recorder only, the recorder may be connected with each furnace by means of a system of tubes, and the furnace to be tested is to be switched on. As a matter of fact, one recorder may take care of four to six furnaces in actual practice, where the firemen are accustomed to work by the recorder.



View of the CO_2 Recorder.

The recorder occupies about 3 x 4 ft. of floor space and stands 6 ft. high. The chart must be changed and the clock wound each day. The caustic potash solution must be renewed every week when working night and day shifts, or every fortnight when working day shifts only. The caustic potash solution is made as follows: 395 parts by weight of caustic potash; 875 parts by weight of distilled water; and 1,270 parts by weight of caustic potash, giving a solution of 1.27 specific gravity. The cost of the solution required for one filling is about 30 cents. Metal valves, and other parts requiring fitting and care, are displaced by glycerine, water and oil seals.

Where the load on the boilers fluctuates, as it will in lighting and railway plants, the recorder instructs the fireman how to handle the dampers. The use of the CO_2 recorder enables the manager to get better service from his firemen, and in case of a strike it is possible to get fair results from inexperienced operators. The automatic recorder may also be used in connection with gas-fired boiler installations, several being now in use in conjunction with producer-gas plants.

A Reinforced Concrete Bridge at Mishawaka, Ind.

Cedar St. in Mishawaka, Ind., crosses the St. Joseph River on a 3-span reinforced-concrete bridge, having a total length of 402 ft. The bridge has a width of 40 ft. from center to center of spandrel walls and carries a 28-ft. roadway, with a 6-ft. walk on each side. The three spans are each a 110-ft. three-centered arch, with a rise of 14 ft. The reinforcement of the arch rings is designed and built according to Melan system. This reinforcement consists of latticed girder steel ribs, which are arranged in a manner similar to the arrangement of the reinforcement ribs in a number of bridges of the same type that have recently been described in this journal. The concrete in the piers and abutments was made in the proportions of 1 part of Portland cement, 3 parts sand and 6 parts gravel. The concrete for the arch rings was made in the proportions of 1 part Portland cement, 2 parts sand and 4 parts broken stone.

The bridge is one of the simplest structures of this type that has been built, and involves few unusual features in its design. The construction of the bridge was carried on under unusual conditions, however, practically all of the concrete being laid in winter, and some it when the temperature was as low as zero degrees Fahrenheit. The bridge has been completed three years, but so far as it is possible to discover no deleterious effects have resulted to the concrete laid during the extreme cold weather.

Cedar St. Bridge, Mishawaka, Ind.

The work had to be carried on during the winter owing to a number of unavoidable circumstances that arose before and after the construction was started. The concrete in the piers and abutments was not all laid until about Dec. 15, although prior to that time the falsework and centering for one arch and for part of a second had been erected. It had become evident by the time this amount of work had been done that the concrete work would have to be completed and the falsework removed before the ice that had formed in the river went out, or the falsework and a part of the bridge would be lost. The bridge is about ¾ of a mile above the dam of a water-power development, which dam forms a mill pond that extends for some distance above the bridge. The heavy ice which forms over this pond generally goes out in a mass during a thaw, so that some damage was sure to be done to the bridge if it was in an unfinished condition when such a flow of ice took place.

The falsework and centering for all three arches were, therefore, completed as rapidly as possible and concrete laying was started in the arch rings about Jan. 1. The concrete mixing plant was set up on one bank of the stream and was entirely enclosed by a frame building after cold weather started. A low trestle carrying two tracks was built across the river just upstream from the bridge and the tracks on this trestle extended to the mixing plant. Practically all of the concrete was handled on these tracks between the plant and the bridge in bottom-dump wooden car bodies on 4-wheeled trucks. The car bodies were lifted from the trucks by a derrick and swung to the place where the concrete was to be deposited.

When the temperature was below freezing the broken stone, gravel and sand were heated, but no salt was added to the concrete. The stone, gravel and sand were delivered to the work on a standard-gauge track. A pit was excavated under this track and fitted with a number of pipe coils, which were supplied with steam during freezing weather from a boiler of the mixing plant. The materials were thoroughly heated in this pit before being used in the concrete, their average temperature at the mixer being somewhat above blood heat. As soon as the concrete was laid in the bridge it was covered with tar paper or boards to protect to some extent from the weather. The fresh concrete in the bridge would hold its heat for several days. In one instance snow falling on concrete that had been laid 48 hours was readily melted, although the temperature of the air was well below the freezing point.

While the concrete in the arches was being laid 12 to 15 in. of ice formed over the entire pond above the bridge. Nineteen days after the last arch concrete had been laid a warm rain set in resulting in the entire ice floe starting downstream. The ice piled up above the bridge for a time, but finally the gorge split on the cut-waters of the bridge piers and carried away the falsework and centering of the middle span. This occurred 19 days after the concrete had been laid in the arch but did not result in any damage to the bridge. The falsework of the other two spans was damaged by the gorge, but was not entirely carried away.

The bridge was designed by Mr. A. J. Hammond, as consulting engineer to the commissioners of St. Joseph County, and was built under his direction. The H. E. Talbot Co., of Dayton, Ohio, was the contractor for the erection of the bridge, the contract price for which was $61,669.

The Manufacture of Brick from Refuse of a gas works plant is practiced at Leeds, England. Lime is there used for purification of the gas and spent lime, formerly wasted, is now mixed with clinker waste and calcined in a kiln at an intense heat for 18 hours, the heat being obtained by means of a producer and abundant air supply in the kiln. After calcination the material is spread out on a floor, allowed to cool and then thoroughly slaked. It is then ground and passed to a mixer where more clinker is added, and then passed to a two-mold press which forms 1,000 brick per hour. They are hardened by subjecting them to steam pressure of 120 lb. in close cylinders for 14 hours, after which they are ready for use.

Letters to the Editor.

Reinforced Concrete at Stanford University.

Sir: I have just noticed Mr. Ransome's letter to you under date of May 15. I was told by Mr. Kedtinge, Mr. Ransome's superintendent of construction, when Roble Hall and the Museum at Stanford University were built, that there is no steel in the walls except at the floor levels. It should be an easy matter for Mr. Ransome to give the details of the construction. I see no reason for changing my conclusion.

Very truly yours, Chas. D. Marx.

Sir: I herewith return you Prof. Marx's letter. On his own showing he was informed that the walls were reinforced at the floor levels, and I am surprised that with this knowledge he should have stated that reinforcement had not been used in its walls. Our usual practice is to place horizontal reinforcement in our walls immediately over and under the line of the windows, which is approximately at the various floor levels. I am not positive, however, whether there was any vertical reinforcement in these walls or not, but I feel sure that vertical reinforcement was placed in every main corner. I regret very much that I am unable at this late day to place my hands upon the detailed drawings of the work.

With regard to the importance of reinforcement in concrete construction, I would draw attention to the fact that the only work under our system which suffered from the effect of earthquake, was some chimneys in which the reinforcement had been omitted through want of proper oversight. On the other hand, the high bell tower constructed by us for the Mills Seminary, near Oakland, has stood the shock without the slightest injury.

Very truly yours, Ernest L. Ransome.
New York, June 11.

Corrosion of Steel Bridges.

Sir: A certain highway bridge, owned by a county, is considered unsafe for the traffic that now passes over it. It was built about ten years ago and has not been painted as often and as well as it should have been, so, as a consequence, has rusted badly. The county officials desire to know what effect the loss of metal, on account of rust, has had. Since the deflection of a framed structure for any given loading can be as rigidly determined, as the stresses in the member can be found, would not the actual deflection from a known load, compared with the computed deflection, based upon the strength of the members when known, be a closely accurate solution of the problem? I will consider it a favor if you will submit this to the readers of the Record, as I will also, any suggestion of comment they may make.

Yours truly,
A. C. Barrow.
Hedges, Ky., June 25, 1906.

Reinforced Concrete Columns.

Sir: Both the letter from Mr. F. F. Weld on the above subject, which appeared in your issue of June 2, and your editorial in your following issue, apparently ignore what seems to the writer to be a fundamental fact in relation to the joint action of concrete and steel in compression. Is it not a fact that the actual stress developed in each material is dependent upon the ratio of their moduli of elasticity? Or, in other words, and by way of illustration, suppose a reinforced-concrete column supporting a given load. The unit stress in the concrete divided by its unit strain or shortening, equals the modulus of elasticity, and the same is true for the steel; and since the strains must be equal in order that the two materials may act together, it follows that the unit stresses are to each other as the moduli of elasticity of the materials. This may be expressed mathematically as follows:

Let C = the safe unit stress in the concrete.
Let S = the safe unit stress in the steel.
Let $1c$ = strain in concrete due to C.
Let $1s$ = strain in steel due to S.
Let Es = moduli of elasticity for steel.
Let Ec = moduli of elasticity for concrete.

Then $C/1c = Ec$, and $S/1s = Es$; but $1s = 1c$; therefore $C/S = Ec/Es$. If we assume that $Ec/Es = 1/10$, which is approximately true, then we have $C = 1/10\ S$, which is a ratio entirely independent of the relative amounts of concrete and steel, and if $C = 500$ lb., we cannot get more than (about) 5,000 lb. per square inch in the steel. Of course if the reinforcing is so designed that it can act independently as a strut, an excess of load beyond the point indicated, would simply result in throwing the entire weight on the steel and this would undoubtedly happen after the elastic limit of the concrete was reached.

The obvious conclusion seems to be that the use of reinforcing except for the purpose of resisting bending stresses is uneconomical, and that in a case such as that cited by Mr. Weld, where the necessary size would preclude the use of a concrete column, the only permissible design would be a steel column to carry the whole load, with a concrete casing for fireproofing only.

The fine cracks that are observed in the lower part of a reinforced beam, which usually develop before the limit of safe loading is reached, tend to demonstrate the correctness of this theory. The steel and that part of the concrete which is below the neutral axis would act together in tension until the elastic limit of the latter was reached (the steel having a unit stress at that time of perhaps 1,000 lb.) when the concrete would yield, throwing the whole tension on the steel, and the correctness of the best American practice in assuming that the reinforcing takes all the tension is thus theoretically demonstrated.

Respectfully,

W. M. Farrar.

New York, June 27.

A Formula for Reinforced Concrete.

Sir: The accompanying rough analysis of a formula for reinforced concrete may be worthy of publication. The following assumptions used in the development of the formula are based on those required by the Building Code of New York City:

All tension is assumed to be taken up by the steel.

a = area of steel per unit width.

The stress curve is assumed as a straight line (New York Building Code).

Es = modulus of elasticity of steel.

Ec = modulus of elasticity of concrete.

C = compression per square inch of concrete in extreme fibre = 500 lb. (New York Building Code).

S = tension per square inch in reinforcement steel.

$\dfrac{Es}{Ec} = 12$ (New York Building Code).

b = width = 1 in this discussion.

d = distance from centre of gravity of steel to top of beam.

h = distance from neutral axis to top of beam.

The amount of tension per square inch in reinforcement steel, S, is taken to be the same as in the following analysis derived by Capt. John S. Sewell, Corps of Engineers, U. S. A.:

λc = Total compression of concrete in the length dl.

λs = Total elongation of steel in the length dl.

$\dfrac{\lambda c}{dl}$ = Compression per unit of length of concrete.

$\dfrac{\lambda s}{dl}$ = Elongation per unit of length of steel.

$$Ec = \frac{C}{\frac{\lambda c}{dl}} = \frac{C \times dl}{\lambda c} \quad \dots\dots (1)$$

$$Es = \frac{S \times dl}{\lambda s} \quad \dots\dots (2)$$

From equations (1) and (2)

$$\frac{\lambda c}{\lambda s} = \frac{C \times Es}{S \times Ec} \quad \dots\dots (3)$$

Now by similar triangles

$\lambda c : \lambda s :: h : (d\text{-}h)$.

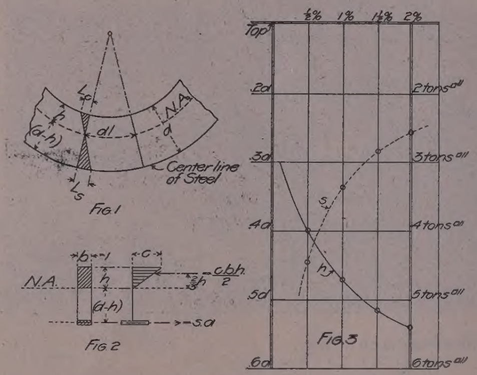
$$\frac{\lambda c}{\lambda s} = \frac{h}{(d\text{-}h)} \quad \dots\dots (4)$$

Put equation (3) = equation (4).

$$\frac{C \times Es}{S \times Ec} = \frac{h}{(d\text{-}h)}.$$

$$C = \frac{h \times S \times Ec}{(d\text{-}h)\ Es} \quad \dots\dots (5)$$

$$S = \frac{C\ (d\text{-}h)\ Es}{h \times Ec} \quad \dots\dots (6)$$



Diagrams of Analysis.

Now from Fig. II, having S, the following analysis may be made:

$$S \times a \cdot (d\text{-}h) = \frac{c \times b \times h}{2} \times \frac{2h}{3};$$ if $b = 1$, we get, $$s \times a\ (d\text{-}h) = \frac{C \times h^2}{3} \quad (7).$$ Substitute value for s found in equation (6) and equation (7) becomes $$\frac{a\ (d\text{-}h)^2\ C \times Es}{h \times Ec} = \frac{C \times h^2}{3} \quad (8).$$ Solve equation (8) for d; $$d = h \sqrt{\frac{h}{3a\frac{Es}{Ec}}} + h \quad (9),$$

If $\dfrac{Es}{Ec} = 12$, then $$d = \frac{h}{6}\sqrt{\frac{h}{a}} + h \quad (10).$$

Assume values for h, a and $\dfrac{Es}{Ec}$ and then a curve may be plotted for each different value of h and thus d may be found.

$$\text{Resisting moment of beam} = \frac{2 \times b \times c \times h^2}{3} \quad (11).$$

If a value is assumed for S, then the value for C found in equation (5) should be used.

The writer plotted seventeen curves for h, assuming from 2 to 18 in. and a = .02 to 0.6 square inch, using equation (10).

The table given below was derived from these 17 curves. If the safe crushing stress in concrete is 500 lb. per square inch, then for

$$\left.\begin{aligned} \tfrac{1}{2}\%\text{ of steel } M''\text{ tons} &= \frac{16bd^2}{600} \\ \tfrac{3}{4}\%\text{ of steel } M''\text{ tons} &= \frac{19bd^2}{600} \\ 1\%\text{ of steel } M''\text{ tons} &= \frac{22bd^2}{600} \\ 1\tfrac{1}{2}\%\text{ of steel } M''\text{ tons} &= \frac{26bd^2}{600} \end{aligned}\right\}\ b \text{ and } d \text{ in inches.}$$

To secure values of h from the accompanying diagram read from the left-hand column, which gives the distance from top of beam to neutral axis. To secure stress per square inch of steel read from the right-hand column of the diagram.

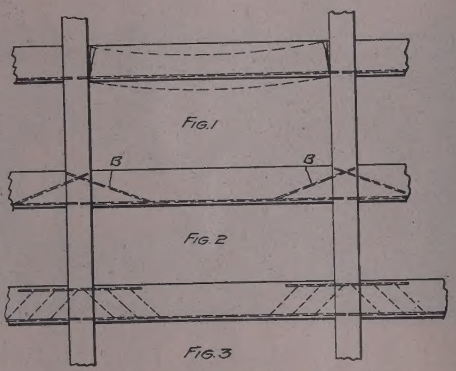
Very truly yours,

W. W. Pearse.

New York, June 6.

Allowable Shear on Concrete.

Sir: The writer has been very much interested in your discussion of the design of reinforced concrete columns and beam connections. We talk glibly of the 50-lb. allowable shear at the ends of concrete girders, and indeed as long as the concrete remains intact, good concrete should bear this safely. But suppose the beam to be reinforced against bending only, by placing straight horizontal bars near its bottom as in Fig. 1. Then suppose the beam to deflect slightly, so that a crack, microscopic, perhaps, but still a crack, develops near the column extending from the top down into the beam. Our 50 lb. per square inch is gone in an instant, and the beam is endangered.



Methods of Reinforcement.

It is the practice of many engineers to bend up one or more bars, say at the quarter point, **and to lap them at the center** of the column as in Fig. 2. The writer does not believe this to be the most efficient method, because the distance from the top of the bar to the top reinforcement increases so rapidly that a crack is still liable to develop, as at B, in Fig. 2. It seems to me then that the top reinforcement bar should be carried horizontally for a sufficient length to effectually guard against these cracks, and thus insure that the concrete remain intact, and that any additional shearing stresses, which would overtax the allowable shear on the concrete, should be taken care of by diagonal members, as in Fig. 3.

Yours truly,

C. H. Marquess.

Baltimore, Md., June 21, 1906.